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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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The 1930 Census of Production

We have from time to time emphasised the importance of the periodical census of production, as an index to industrial productivity in this country. It is unfortunate that the last census, taken in 1930, should not be available until now. The former year was one of depression and the present one of comparative prosperity, so that comparisons and inferences are difficult. There is nothing wrong with the reliability of British statistics, but the length of time it takes to get any benefit from them compares very unfavourably, for example, with the United States. The figures for specific industries have been issued from time to time, and we have already referred to the founding industry. Something was achieved in getting foundries separately treated at all, this being done in the 1930 census for the first time, but much more is needed. The number of ironfoundries for which statistics were recorded is something like one-third or one-half of the total, and figures for non-ferrous foundries could not conveniently be separated from those relating to the wrought side. Is it too much to ask that the next census shall be taken and reported while the results are still useful for determining industrial policy?

The 1924 and 1930 figures offer no assistance with regard to the founding industry, since the only figures available for the industry were taken, inadequately, as indicated above, for the latter year. Generally, however, some interesting points emerge. The industrial development of the South is shown by the fact that Greater London and the South of England (excluding Lancashire, Yorkshire, the Midlands and North) contributed no less than 43 per cent. of the net output of the United Kingdom, compared with 37 per cent. in 1924. The net output per worker was practically the same, £211 in 1930 and £212 in 1924. The former year saw some 80,000 fewer employed in spite of the depression, the unemployment of the depression being felt mainly on account of the increased population. Engineering and shipbuilding had an output per worker very similar to the average for the whole country, £201 in 1924 and £214 for 1930. The effect of the depression in iron and steel is shown in similar values, £198 in 1924 and £186 in 1930. Yet in petrol refining the net output per worker rose from £502 in the former to £1,016 in the latter year. In every industry the growth of use of electric power continues. To the total power used in the industry the proportion of electric power increased from 46.2 to 54.9 per cent.

Important New Knowledge

A serious defect in the position of British research work into the properties of moulding sands at high temperatures is remedied by the publication on page 411 of this issue of a number of original experiments made by Mr. F. Hudson in the laboratories of Messrs. Glenfield & Kennedy, of Kilmarnock. It was already known that the permeability of moulding sands decreased with increasing temperature, and, as expansion is the natural corollary of heat application it was also realised that sands must be affected, yet the extent of this influence has not yet been fully appreciated. Mr. Hudson has given us some representative figures centering around 1 per cent., with marked variations at 1,000 deg. C., but we still require better data as to the temperature reached by the "business" face of sand moulds after being filled with typical yet diverse kinds of metal. The most important phase of the research is that devoted to the strength of mould materials at higher temperature. Here entirely new ground has been broken and a wealth of information is given, but its main worth is its extraordinary value as a pointer for the elimination of hot tears, cracks, and other defects to be associated with the passage of a casting through the pasty stage. Thus heavy steel castings communicating intense heat to the walls of the mould will render them strong and tough just at the very moment when the metal exhibits a minimum of tensile strength. Obviously, either the strength of the sand must be weakened or the metal bared at critical junctions. Mr. Hudson's research results are so important that it is, to our mind, imperative that they should be confirmed—and the confirmation in justice to the originator broadcast with a minimum of delay. The foundry industry is both cognisant and appreciative of the author's previous work, but this latest effort certainly warrants their unstinted thanks.

XUM

Small Blowers

A NOTABLE ROTARY DESIGN

For many operations in foundries, and engineering establishments generally, such as the working of oil and gas burners, low-pressure sand blasting, and the air cleaning of dies and other parts of machinery, it is convenient to use small, independent, separately-driven blowers. For this purpose the Holmes-Connersville "Victor" positive rotary blower, a production of W. C. Holmes & Company, Limited, of Huddersfield, is of considerable interest.

Essentially the principle consists of the use of two involute cast-iron impellers, on the same lines as the "Roots" blower, which always inter-engage with one another while rotating at high speed in opposite directions, being each fixed on a separate shaft. The arrangement is contained within an outer cast-iron casing, with the inner surface of which the impellers constantly inter-engage, as well as with each other. Also the two impeller shafts, running on anti-friction or white-metal bearings and ring lubricated, are parallel, being connected together by gearing running in an oil bath outside the casing, and driven through a very short single shaft in any convenient manner, such as by a direct-coupled electric motor or a belt.

The workmanship is of an extremely high-grade character, the impellers being made so that the actual clearance between the two at all points of their travel is approximately 0.002 in. (two-thousandth), and the same applies to the clearance between the impellers and the casing. Under these circumstances there is no actual contact, and internal lubrication is therefore not necessary, the air being delivered as clean as when it entered the machine, although a high volumetric efficiency is obtained. The two involute impellers, as they revolve at high speed, draw air through an inlet into the constantly-changing "pockets" or spaces between themselves and the casing, and carry it to the outlet, giving a constant flow of air without surging. Important also is the low velocity of the air, while the whole action is simple and positive, and included is a patent non-vibratory pressure relief valve.

A wide range of these blowers is available, and they can also be operated as vacuum pumps, one important point being the supply of a constant volume of air regardless of pressure differences, while the operating range for compressed air is up to 5 lbs. per sq. in., with as high as 10 in. mercury under vacuum operation conditions.

Typical small sizes run at 500-1,200 r.p.m., delivering, say, 26 to 420 cub. ft. of free air per min. at ½ lb. per sq. in. pressure, or 23 to 400 at 1½-lb. pressure, taking only 0.3 to 3.6 h.p. Representative of one of the larger machines is a speed to 700 r.p.m., delivering from 280 cub. ft. of free air per min. at ½ lb. per sq. in. pressure to 230 cub. ft. at 5-lb. pressure, taking 0.9 to 7.7 h.p., according to the air pressure. Machines for higher pressures and larger volumes are also available.

British Foundry School

The student roll for the present session of the British Foundry School has been completed by a nomination from Duport Foundries, Limited, Dudley Port, additional to the original list published in our issue of October 24, 1935. The following further contributions to the funds required for the current year have also been received, leaving £87 to be obtained:—Mr. M. H. Curnow, West Bromwich, £1; Mr. W. J. Flavell, J.P., West Bromwich, £1 1s.; Manganese Bronze & Brass Company, Limited, London, £3 3s.; C. & B. Smith, Limited, Wolverhampton, £5.

The New Science of Artificial Radioactivity

Some important features of the new science of artificial radioactivity were dealt with by Prof. F. Paneth, of the Imperial College of Science and Technology, London, in an address on the subject of "Artificial Radio-Elements" before the Newcastle Section of the Society of Chemical Industry on November 22.

The production of artificial radio-elements, he said, was the newest development of the old science of alchemy. It was of special interest for the chemist, as up to the present the quantities produced by artificial transmutation were too small for a purely chemical examination; if, however, the newly-formed elements were radioactive, the much higher sensitivity of electrometric apparatus could be used for a study of their chemical properties, and in this new field the collaboration of the chemist with the physicist was as necessary and as fruitful as in the realm of the natural radioactive elements.

Production of Artificial Radio-Elements

Artificial radio-elements could be produced in many ways: by bombarding the elements with various kinds of rays of radioactive substances; with hydrogen or deuteron particles accelerated by electric fields; with X-rays; and with neutrons. The efficiency of neutrons in transforming elements depended largely on their velocity, and was in most cases much increased by slowing down the neutrons by collision with hydrogen atoms.

Prof. Paneth showed experiments to demonstrate the activation of fluorine, rhodium, and silver by fast and slow neutrons, and the decay of the artificial radio-elements produced.

A few elements, he said, possessed a special facility for absorbing slow neutrons; the neutron-nucleus collision cross-sections of the elements boron, cadmium and gadolinium exceeded those of other elements by a factor of about 300, 3,000 and 30,000 respectively.

Among the many interesting features in the new science of artificial radioactivity were the creation of at least one new radioactive series and the production of elements of higher atomic number than uranium. On the practical side it was worth mentioning that the artificial radio-elements might be used in the same way as the natural ones as indicators in the study of many chemical, physical, and biological problems; for example, the phosphorus metabolism in rats had recently been investigated by this method.

The ease with which, throughout the periodic system, elements can be experimentally transmuted, Prof. Paneth said in conclusion, goes far towards clarifying our ideas about the way in which the creation of the natural radioactive elements as well as of the stable elements has taken place.

British Iron and Steel Corporation

TO UNDERTAKE FEDERATION'S SELLING ACTIVITIES

A private company, styled the British Iron & Steel Corporation, has been formed to carry on the selling activities of the British Iron and Steel Federation. Both imports and exports of iron and steel will come within the scope of the new Corporation, which has been specially formed as a body which, on behalf of the industry as a whole, can enter into contracts and financial commitments. The constitution of the Federation rendered desirable the formation of a separate body. Mr. I. F. L. Elliot, of the British (Guest Keen Baldwins) Iron & Steel Company, Limited, is expected to direct the activities of the new Corporation.

Outlook for Lead

BY "ONLOOKER."

Lead has had rather a wonderful run this year, and although imports into this country have not much exceeded those in 1934, prices have been better and the outlook is greatly improved. Up to the end of October imports of pig lead into the United Kingdom totalled 264,000 tons, more than half of which came from Australia, while Canada at 71,000 tons was responsible for about half the Australian tonnage. Burma sent some 36,000 tons, so the geometrical progression of these contributions from Empire countries is preserved! Between them Mexico and the United States shipped only 10,000 tons to these shores, so that it is evident our dependence on sources other than British is very slight. For this the duty on foreign lead is responsible, and although the incidence of this tariff was changed when in August the revised rate of 7s. 6d. was introduced, it has not so far operated in favour of foreign brands which are continuing to go to the Continent.

What has happened, however, is that a drastic reduction has taken place in the stocks of foreign lead in bonded lead in our official warehouses, for at the end of September these stood at only 6,000 tons compared with 15,000 tons six months earlier. These figures speak for themselves and indicate an all round shortage of lead, for not only has metal been withdrawn for consumption in this country, but there have also been re-exports to the Continent. During November it rather looked as if the comparative scarcity of spot metal would bring a backwardation in the price into being on the metal exchange, but this did not occur, although it would be unwise to conclude that all risk of this is past. Latterly sales on 'change by interests representing Australia have been heavy, and it is evident that when consumptive demand falls off temporarily the Commonwealth producers do not intend to forsake a market which gives them a handsome yield by virtue of the exchange rate between this country and Australia.

Some idea of the strength of the lead position may be deduced from the fact that the price of this metal now stands £2 higher than that of spelter, which it passed in the race for supremacy in value some months ago. The rate of spelter production is, of course, controlled, although the zinc cartel is no longer in being, but lead stands on its own feet and is free from any kind of artificial control, a fact which makes the position much more stable and leaves little or no room for serious price recessions. Minor setbacks in the lead quotation we have seen, but the undertone is very firm, and in the opinion of those well fitted to judge a further upward movement in the near future is quite likely to occur.

The rise in lead values this year has been almost phenomenal, the advance amounting to an appreciation of more than 50 per cent. since the early months when the price ruled between £10 and £11. Consumption is better than it was last year by at least 10 per cent., and for this eminently satisfactory state of affairs we have to thank the continuance of the building boom, which in spite of fears expressed to the contrary appears still to be going strong! Perhaps the peak has been reached, although even here there are doubts, but it does not seem that the market need look for any falling off for some time to come. Secondary lead is, of course, a factor to be reckoned with, for with slum demolition and a big return from storage batteries it looks as if 1936 will see a good deal of scrap lead available for consumption. Nevertheless the outlook is favourable for the coming months.

AN ORDER for railway axles for the Egyptian State Railways Administration has been placed with the Glasgow Railway Engineering Company, Limited, Govan.

Some Properties of Mould and Core Materials at Elevated Temperatures*

By FRANK HUDSON

Now that the routine testing of mould and core materials is rapidly becoming established in many foundries there is a great need for research relative to the properties of these materials at elevated temperatures. It is obvious that the properties of sand in a mould at room temperature will not be the same when it is heated by the casting of the metal into that mould. For instance, one of the major problems of the steel founder is that of contraction cracks and there is no doubt that some reliable information relative to the question of sand expansion in conjunction with the strength of the sand at elevated temperatures will be helpful in the elimination of these defects. It is known that the additions of such substances as coal dust, sawdust, old crucibles, crushed firebricks, horse dung, oils, etc., profoundly effect the production of castings, but the technique of their action is quite another story. Perhaps some knowledge of the true function of these substances will be obtained by high temperature study. The need of information on the properties of mould and core materials at elevated temperatures is not alone to the steel-founder, although perhaps his need comes first. The iron-founder does succeed in producing a few cracked, scabbed and other sorry looking objects which could have undoubtedly been used for the services of man, instead of being given an ignominious grave, if the text of this Paper had been in evidence. Even the non-ferrous founder can conjure innocent objects of his own production back into the melting pot in a most mysterious manner yet perforce have to suffer seeing the worst casting ever produced occupying a most conspicuous place in the machine shop. It is hoped that the results published in this Paper may in some measure lead to a more peaceful life in the non-ferrous foundry notwithstanding a saving in fuel.

TABLE I.—*Materials used in the Investigations.*

Designation.	Mixture.
Steel foundry "Compo."	Proprietory.
Iron foundry green sand	98.9 per cent. green sand floor sand. 0.7 per cent. Scottish rotten rock. 0.3 per cent. coal dust. 0.1 per cent. wood extract. (Milled for 2 min.)
Iron foundry dry sand ..	98.9 per cent dry sand floor sand. 1.1 per cent. Bentonite. (Milled for 10 min.)
Oil sand	87.0 per cent. Irvine sea sand. 10.0 per cent. Scottish rotten rock. 3.0 per cent. Semi-solid core oil. (Mixed for 5 min.)
Brass foundry green sand	Wormit red sand. (Milled for 5 min.)

A review of previous work conducted relative to the study of mould and core materials at elevated temperatures is not a difficult task. Apart from some investigations upon the refractoriness of foundry sands, the effect of heat upon permeability and expansion tests, one can find little else of value. Much of the present knowledge of high temperature effects in the foundry is due to workers in the refractory field and there is definitely room for original investigations from the foundry viewpoint. During the past few years work of this nature has been forthcoming from the United States of America through the efforts of D. W. Trainer Junr., W. M. Saunders, H. W. Dietert, and A. H. Dierker. From Sweden, by Sixten O. V. Nilsson and from Germany by F. Maske and E. Piwowarsky. The available foundry literature in this country, however, does not contain records of any British investigation directly connected with the properties of mould and core materials at elevated temperatures and it is hoped that this present work will help to correct this omission and at the same time contribute in a small way to the progress of the trade as a whole.

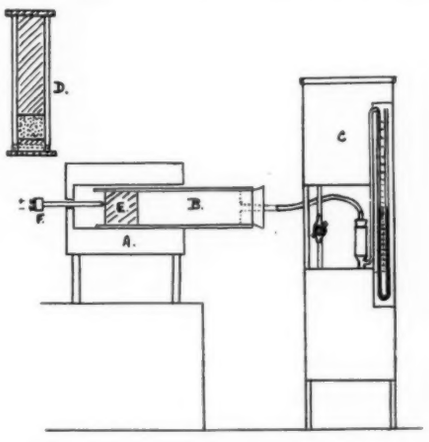


FIG. 1.—APPARATUS FOR DETERMINING THE EFFECT OF HEAT ON PERMEABILITY.

A. Electric furnace. B. 2-in. bore vitreosil. C. Richardson's permeability apparatus. D. Method of ramming test-piece. E. Sand test-piece. F. Pyrometer.

The effect of heat on the properties of five samples of mould and core materials has been investigated, the designation of these samples being given in Table I. The normal physical properties of the sands at room temperature are indicated in Tables II and III.

TABLE II.—*Properties of Materials Used.*

Designation.	App. density.	Per cent. moisture.	Compression A.F.A. lbs. per sq. in.		Permeability. A.F.A. No.		Per cent. loss on ignition.
			Green.	Dried.	Green.	Dried.	
Steel foundry "compo."	1.78	7.8	7.5	143.0	—	49	4.42
Iron foundry green sand	1.51	6.7	5.2	46.4	77	—	16.13
Iron foundry dry sand	1.74	9.1	7.0	155.5	—	69	4.60
Oil sand	1.46	—	1.4	336.0	—	223	3.88
Brass foundry green sand	1.75	7.3	6.5	133.4	22	—	8.51

TABLE III.—*Sieve Test on Materials Used.*

Designation.	Per cent. clay.	Sieve test. Per cent. passing mesh.							
		20	30	40	60	80	90	100	120
Steel foundry "compo" ..	17.1	69.1	61.4	42.4	38.3	29.3	24.3	17.2	15.0
Iron foundry green sand ..	13.9	96.3	92.6	87.1	45.6	22.8	18.2	15.8	13.4
Iron foundry dry sand ..	17.5	89.3	83.7	77.8	43.5	24.8	20.1	15.6	14.4
Oil sand	3.1	97.7	89.1	60.6	18.9	4.0	2.2	1.3	1.0
Brass foundry green sand..	13.8	96.8	95.7	92.8	71.5	50.4	44.7	38.1	35.3

The Effect of Heat on Permeability

The apparatus used for determining the effect of heat on permeability is illustrated in Fig. 1. The sand sample E under test is rammed by double-compression, as shown at D, in a vitreosil tube B. To minimise the chance of gas leakage between the sand and the vitreosil tube, the surface of the tube in contact with the sand is coated with plaster of Paris and the test section rammed into place before the plaster has completely set. The tube is next placed in the electric furnace A, having temperature controlled by pyrometer F, and connected to Richardson's permeability apparatus C. The first permeability determination is conducted at room temperature, and then the furnace is switched on and determinations conducted at every 50 deg. C. rise in temperature up to 200 deg. C., and every 100 deg. C. thereafter. At every test point the furnace temperature was maintained for 10 min. to ensure the penetration of heat to the centre of the specimen. It should be pointed out that the size of test-piece employed is 2 in. dia. × 2 in. long, and the permeability number determined by the passage of 2,000 ccs. of air exactly similar to the standard method recommended for the testing of sand at normal temperatures. Attention is particularly drawn to this latter statement in view of the work conducted in the United States on this question by Saunders.[1, 2]

Saunders employed a test-piece 1 in. dia. × 2 in. long and measured the permeability by momentary pressure readings. Apart from these modifications the tests conducted by the present author are on similar lines to those done by Saunders, but it was felt that by using the standard size of test-piece the results obtained would be directly comparable with recommended practice. Furthermore, Saunders measured the permeability by momentary pressure readings, as he considered that the passage of 2,000 ccs. of moist air through the silica tube would tend to complicate the determination of the pressure, especially at the higher temperatures employed. In view of the enormous effect of gaseous expansion when the cold air comes in contact with the heated sand sample, it was considered that the measurement of permeability by pressure alone was inaccurate, and it would be advisable to conduct the test in the usual way. Accordingly in all the tests conducted the permeability number was obtained by passing 2,000 ccs. of air through the silica tube and noting the pressure after half the air had passed. It was found that this amount of air had little or no cooling effect on the test-piece when the $\frac{1}{16}$-in. jet was employed in the permeability apparatus.

Fig. 2 illustrates the effect of heat on the permeability of the various sands tested as previously described. These results are similar to those obtained by Saunders. At first sight one might naturally conclude that the effect of heat markedly decreases the permeability value of mould and core materials. Saunders puts forward this conclusion, and also tenders the

* Paper read before the East Midlands Branch of the Institute of British Foundrymen, Mr. J. F. Driver presiding.

suggestion that the breaks shown in the continuity of the curves obtained are due to the effects of other gas forming substances such as moisture or oil binders, whilst the decrease in permeability is due to the expansion of sand grains cutting down the flow of air. In these tests, however, the greatest factor of all has not yet been taken into account—namely the expansion of the air due to heat as it passes through the sand test-piece. Very few founders fully appreciate the enormous effect of this change. If instead of using the large 2-in. bore silica tube and its sand test-piece, a $\frac{1}{16}$-in. tube is substituted and the foregoing experiments repeated, some interesting results are obtained, as shown in Fig. 3. It will be observed that a $\frac{1}{16}$-in. vitreosil tube has a permeability number at room temperature of about 22, which decreases down to about 3 at 1,000 deg. C., as shown by the full line curve. Vitreosil, however, is not affected by heat of the degree shown, and, practically speaking, does not contract or expand. Consequently it can be very positively stated that the bore of the tube has not altered, and consequently neither has the true permeability, which must still be the same, namely 22, at 1,000 deg. C., as shown by the broken line. The reason why the test method indicates a decrease in the permeability is due to the fact that whilst one employs 2,000 ccs. of air at normal temperature and pressure, at 100 deg. C. the 2,000 ccs. has expanded to 2,900 ccs., at 500 deg. C. to nearly 6,000 ccs., and at 1,000 deg. C. to nearly 15,000 ccs. These figures can be easily arrived at by employing the results obtained in Fig. 3 in conjunction with the usual permeability formula, and are plotted in Fig. 4. Now if the original permeability values, as indicated in Fig. 2, are corrected for the degree of air expansion at various temperatures, the true effect of heat on the permeability of mould and core materials can be indicated, as shown in Fig. 5. The corrected figures clearly indicate that the true permeability is not affected by heat. Theoretically this statement requires that the curves indicated in Fig. 5 should exist as straight lines, but it should not be forgotten that only the effect of heat on the expansion of the air used in the test has been taken into present account. All foundry sands contain either moisture or carbonaceous matter, and through the effects of heat these elements are turned into steam or gas, which goes to increase the degree of expansion already occasioned by the air. Furthermore, the volume of gas evolved should be corrected for pressure, as shown in Table IV. It was not found possible to allow for these additional factors in the present calculations, and this causes the curve to depart from the theoretical straight line. Once the majority of the gas-forming substances have been removed by heat the permeability figure rises and at 1,000 deg. C. the present tests clearly indicate that the permeability of mould and core materials is greater than at room temperature. A fairly accurate idea of the effects of heat on the permeability should be obtained from Fig. 5 by joining the result at room temperature with that at 1,000 deg. C. The increase in permeability

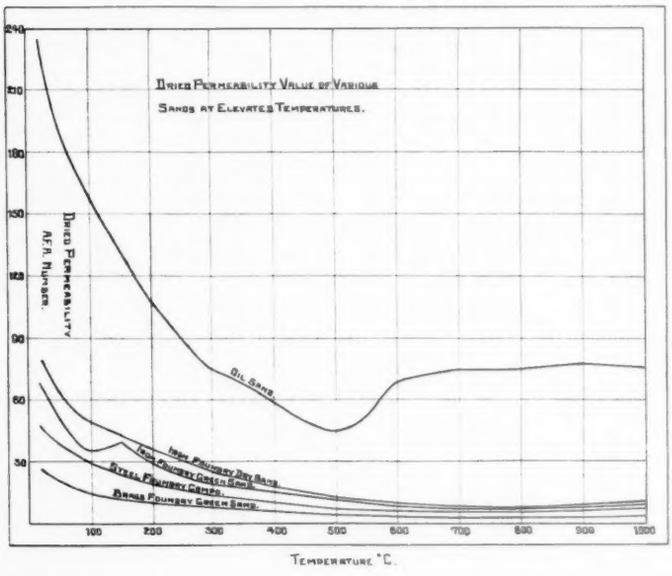

Dried Permeability Value of Various Sands at Elevated Temperatures.
Dried Permeability A.F.A. Number.
Oil Sand.
Iron Foundry Dry Sand.
Iron Foundry Green Sand.
Steel Foundry Green Sand.
Brass Foundry Green Sand.
Temperature °C.

FIG. 2.—DRIED PERMEABILITY VALUE OF VARIOUS SANDS AT ELEVATED TEMPERATURES.

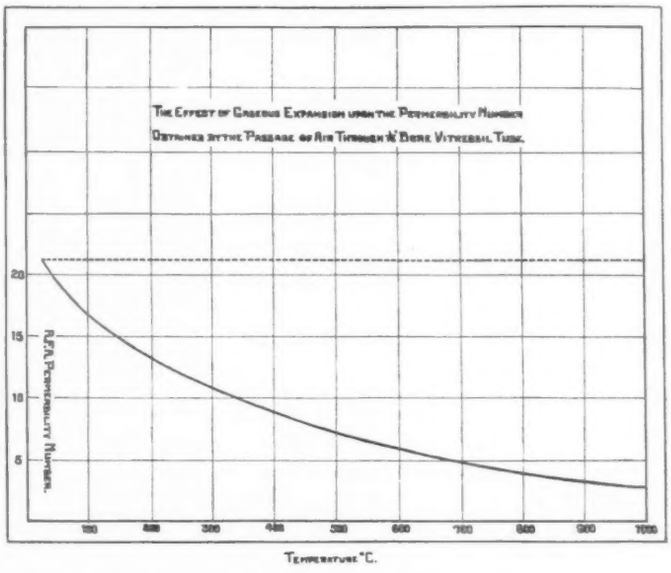

The Effect of Gaseous Expansion upon the Permeability Number Obtained by the Passage of Air Through ¹/₁₆" Bore Vitreosil Tube.
A.F.A. Permeability Number.
Temperature °C.

FIG. 3.—THE EFFECT OF GASEOUS EXPANSION UPON THE PERMEABILITY NUMBER OBTAINED BY THE PASSAGE OF AIR THROUGH $\frac{1}{16}$-IN. BORE VITREOSIL TUBE.

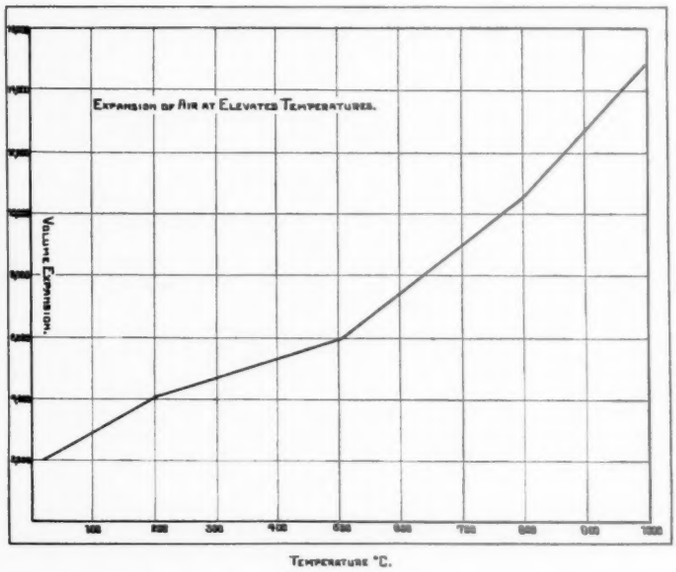


FIG. 4.—EXPANSION OF AIR AT ELEVATED TEMPERATURES.

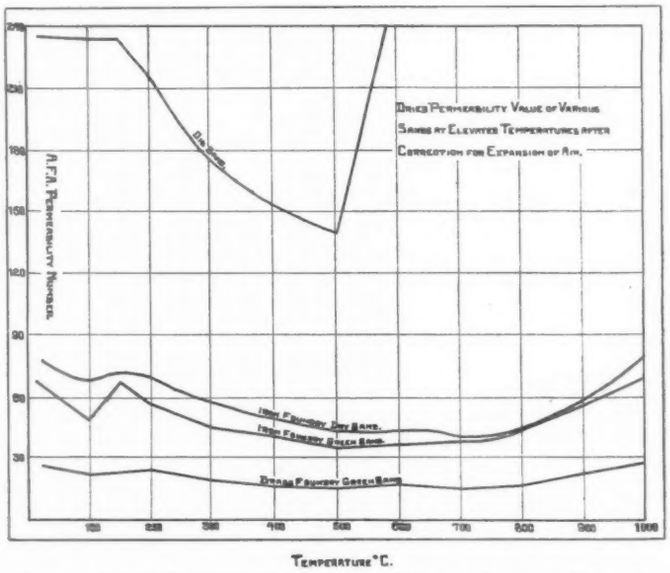

Dried Permeability Value of Various Sands at Elevated Temperatures after Correction for Expansion of Air.
Oil Sand.
A.F.A. Permeability Number.
Iron Foundry Dry Sand.
Iron Foundry Green Sand.
Brass Foundry Green Sand.
Temperature °C.

FIG. 5.—DRIED PERMEABILITY VALUE OF VARIOUS SANDS AT ELEVATED TEMPERATURES AFTER CORRECTION FOR EXPANSION OF AIR.

is probably due to the expansion of the individual sand grains, in conjunction with the promotion of extra voids through the removal of gas-forming elements. This conflicts with the conclusions reached by Saunders, but, quite apart from the experimental evidence, one cannot see how the expansion of sand grains will reduce permeability, and it would appear that unless the very important effect of gaseous expansion be clearly taken in account there is a grave risk of inaccurate conclusions being reached.

Proof that expansion of the sand has little effect on permeability is given in Fig. 6. This graph illustrates the effect of heat on the permeability of a specimen of graded Sillimanite bonded with 5 per cent. sodium silicate. Accurate expansion tests conducted on separate samples indicated that this material, as anticipated, did not appreciably expand or contract when heated. The permeability value, however, is still considerably reduced by the effect of heat. Obviously, it cannot be due to any change in the grain size of the test-specimen itself, as this could not alter. (The actual expansion tests conducted to determine the extent of volume change in the material are illustrated in the section dealing with expansion.)

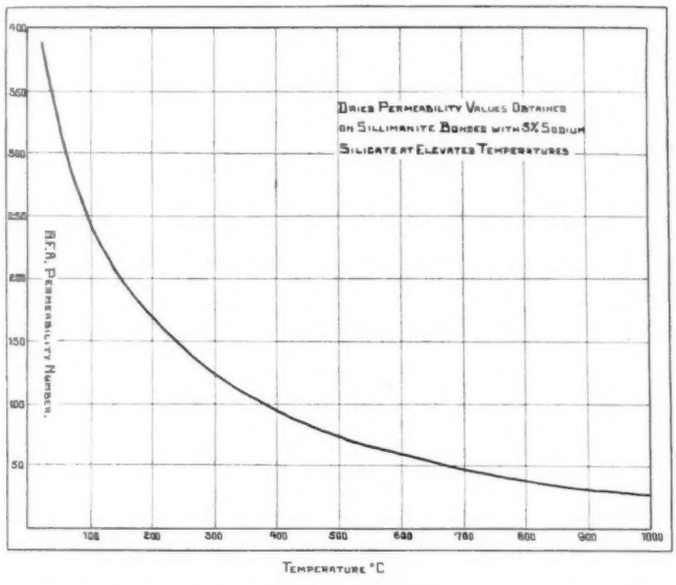

Dried Permeability Values Obtained on Sillimanite Bonded with 5% Sodium Silicate at Elevated Temperatures
A.F.A. Permeability Number.
Temperature °C

FIG. 6.—DRIED PERMEABILITY VALUES OBTAINED ON SILLIMANITE BONDED WITH 5 PER CENT. SODIUM SILICATE AT ELEVATED TEMPERATURES.

TABLE IV.—*Pressure Correction Data.*

Manometer pressure (cms.).	To obtain volume at atmospheric pressure X by
0	1.0
10	1.01
20	1.02
30	1.03
40	1.04
50	1.05
60	1.06

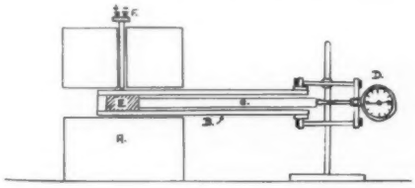


FIG. 7.—APPARATUS FOR DETERMINING THE EXPANSION OF REFRACTORY MATERIAL.

A. Electric furnace. B. Fixed closed-end tube in transparent vitreosil. C. Moving rod in transparent vitreosil. D. Drive micrometer rigidly attached to vitreosil tube. E. Specimen under test. F. Pyrometer.

Conclusions

It can be concluded from these tests that the permeability value for mould and core materials is decreased with increase of temperature. This decrease is principally due to the effect of gaseous expansion and not due to any pronounced structural change, such as expansion or contraction of the materials themselves. The ideal material for foundry requirements would be one that becomes more permeable with increase in temperature in order automatically to allow for the removal of the increasing volume of mould or metal gases. In the absence of this ideal the practical founder should keep in mind that the need of employing mould and core materials of high initial permeability becomes more pronounced as:—(1) The temperature of the metal employed increases; (2) the greater the percentage of gas-forming elements present in the sand or metal; (3) the larger the casting; (4) the higher the pouring speed; (5) the smaller the degree of artificial venting or size of risers employed.

The Effect of Heat on Expansion

The apparatus used for expansion tests is shown in Fig. 7. The lay-out is self-explanatory and is adapted from that used extensively in the refractory trade. It is accepted that this type of equipment is capable of producing very accurate results. The test-piece is $\frac{1}{16}$ in. dia. by 2 in. long, rammed by double compression to the apparent density as shown in Table II, and tested green or, after drying, according to the type of sand employed.

The expansion curves obtained on the various sands are illustrated in Fig. 8. The fact that sands do expand when heated has been known for some considerable time. In 1933 Sixten O. V. Nilsson[3], of the Swedish Manufacturers' Association, drew attention to this fact, and at the last Conference of the American Foundrymen's Association a Paper on the subject was given by H. W. Dietert and F. Valtier.[4] The present investigation indicates that the degree of expansion varies according to the nature of the sand. The addition of materials such as coal dust, saw dust, etc., have a marked effect in reducing the degree of expansion. It is not proposed, however, to go into this side of the question in this present Paper, except to offer it as a possible explanation for one of the reasons why, for example, the ironfoundry green sand has less expansion than the ironfoundry dry sand. At the present time the important points to appreciate are:—(1) The greatest degree of expansion in all the sands investigated takes place between 500 and 700 deg. C.; and (2) the total degree of expansion is of such magnitude as to warrant very serious consideration in the production of castings.

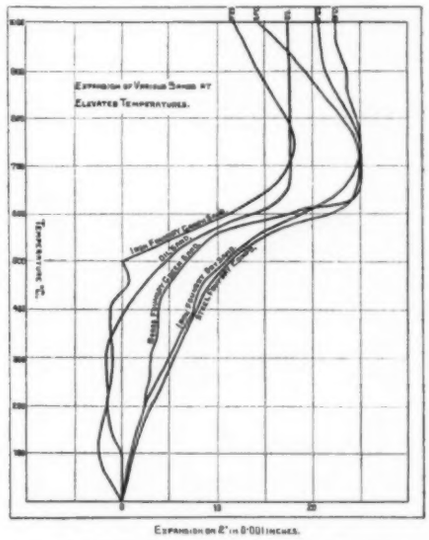


FIG. 8.—EXPANSION OF VARIOUS SANDS AT ELEVATED TEMPERATURES.

The fact that the greatest degree of expansion takes place suddenly, between 500 and 700 deg. C., may possibly lead to the production of defective castings. It should be perfectly obvious that, if during casting one part of the mould is heated to a higher temperature than another, the degree of expansion will vary and buckling of the mould surface may occur. In fact, this does arise very often, due to the design of casting or through incorrect "running" methods. In regard to the total degree of expansion, this varies from 0.109 in. up to 0.149 in. per ft., and the data for all the sands tested is shown in Table V.

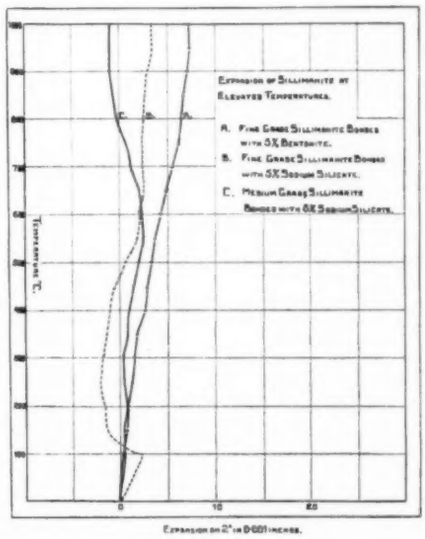

Expansion of Sillimanite at Elevated Temperatures.
A. Fine Grade Sillimanite Bonded with 5% Bentonite.
B. Fine Grade Sillimanite Bonded with 5% Sodium Silicate.
C. Medium Grade Sillimanite Bonded with 5% Sodium Silicate.
Temperature °C.
Expansion on 2" in 0·001 inches.

FIG. 9.—EXPANSION OF SILLIMANITE AT ELEVATED TEMPERATURES.

It is apparent that the degree of expansion is equal to the normal contraction of grey iron and accordingly the question of the expansion of

mould and core materials should be treated with considerable respect, particularly if the expansion is associated with high-compression strength, a factor to be considered in a later part of this Paper. There is no doubt that a sand having as little expansion on heating as possible would be ideal and of great advantage to the founder, and there is no reason why continued research should

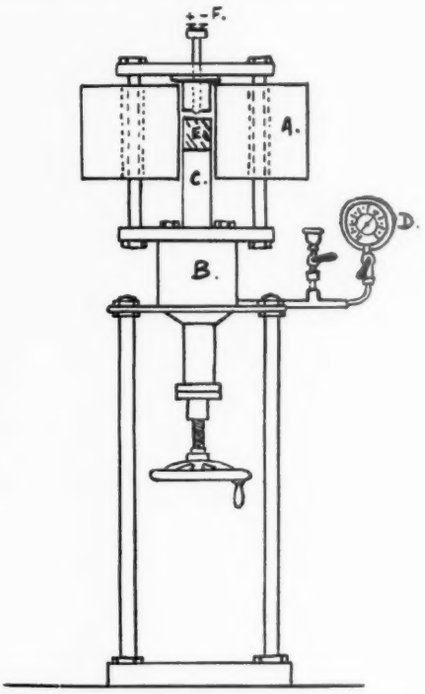


FIG. 10.—APPARATUS FOR DETERMINING COMPRESSIVE STRENGTH AT ELEVATED TEMPERATURES.

A. Electric furnace. B. Oil cylinder for applying load. C. Ni-chrome rams. D. Pressure gauge for indicating load. E. Sand test-piece. F. Pyrometer.

not be productive of something tangible in this direction. For example, if any of the expansion test-pieces be reheated and tested a second time, the expansion will be most markedly reduced. Such an example is given for "iron-foundry dry sand" in Table V, when the initial expansion of 0.146 in. per ft. has been reduced down to

TABLE V.—*Expansion Data on Various Types of Sand.*

Designation	App. Density.	Total expansion per ft. on heating to 1,000 deg. C.	
		Ins.	Per cent.
Steel foundry "compo" ..	1.69	0.126	1.05
	1.78	0.149	1.24
Iron foundry green sand ..	1.51	0.109	0.90
Iron foundry dry sand ..	1.76	0.146	1.22
(Second reheating to 1,000 deg. C.)	—	0.081	0.67
Oil sand	1.46	0.111	0.92
Brass foundry green sand	1.75	0.149	1.24
	1.55	0.142	1.18
Sillimanite bonded with sodium silicate (Fig. 9. C.)	1.60	0.014	0.12

0.081 in. Thus it can be concluded that old sand which has already been subjected to high-temperature effects has a lower expansion than new sand. Another refractory material, known as Sillimanite (anhydrous aluminium silicate) gives very little expansion, and this has already been employed for making semi-permanent moulds for repetition castings. Fig. 9 illustrates the expansion of Sillimanite. In this graph it might be pointed out that sample C is that employed, and previously mentioned, in the tests conducted upon the effect of heat on permeability.

The Effect of Heat on Strength

The previous investigations relative to the effect of heat on permeability and expansion were accomplished without undue difficulty, but when the question of strength at elevated temperatures arose the work became really interesting. In the first place no previous work had been done in this direction by any other investigator and the evolution of the apparatus alone required considerable thought, and even modification, as the work progressed to meet minor unthought of points which came to light. Space does not permit description of the trials and tribulations experienced in the evolution of the equipment until satisfactory operation was obtained with the apparatus as shown in Fig. 10.

The test-piece employed is the usual A.F.A. standard 2-in. by 2-in. section, rammed by the drop-ramming method and broken by the application of compressive loads. The method of conducting the test can readily be obtained from Fig. 10, and further description is superfluous. It should be pointed out, however, that it was found necessary to fit an insert made from material having heat-insulating properties to the bottom ram, to prevent overheating of the oil cylinder at the higher range of temperatures employed. This insert is clearly observed in Fig. 11. The sand samples were slowly heated to prevent the formation of cracks and to ensure uniformity between edge and centre and the heating time averaged about 4 to 5 hrs. Any attempt to hasten this operation invariably resulted in cracked test-pieces and inaccurate results.

The effect of heat on the various sands tested is shown in Fig. 12, and the results obtained are rather startling. It will be observed that, with the exception of "ironfoundry green sand" and "oil sand," the effect of heat increases the strength of the sand to a marked degree. For instance, the dried compression strength of the "brassfoundry green sand" is 133 lbs. per sq. in., at room temperature, and this increases to a maximum of 1,260 lbs. per sq. in. at 900 deg. C. Further increase in temperature causes the strength of the sand to rapidly drop to the low figure of 25 lbs. per sq. in. at 1,000 deg. C. During the first period of strength increase, from room temperature up to 900 deg. C., the test-pieces break suddenly with the usual characteristic shear fracture, but during the period of strength decrease, from

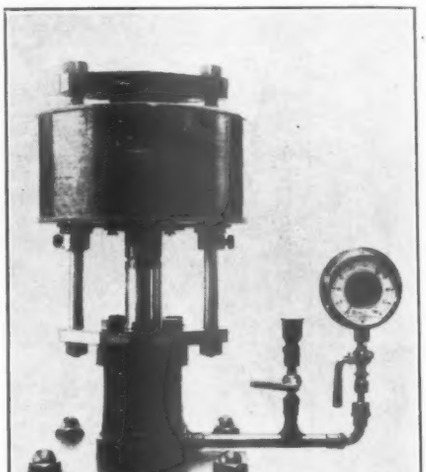


FIG. 11.—VIEW OF THE APPARATUS SHOWN DIAGRAMMATICALLY IN FIG. 10.

900 deg. C. upwards, the effect of heat causes softening of the refractory, with the result that flow takes place and the application of load causes bulging instead of fracture, as shown in Figs. 13 and 14. Consequently, in conducting the compression tests when the degree of temperature reached was sufficient to cause flow, it was found necessary to indicate the compression strength by the load necessary to cause compression of the test-piece by $\frac{1}{16}$ in. on its length.

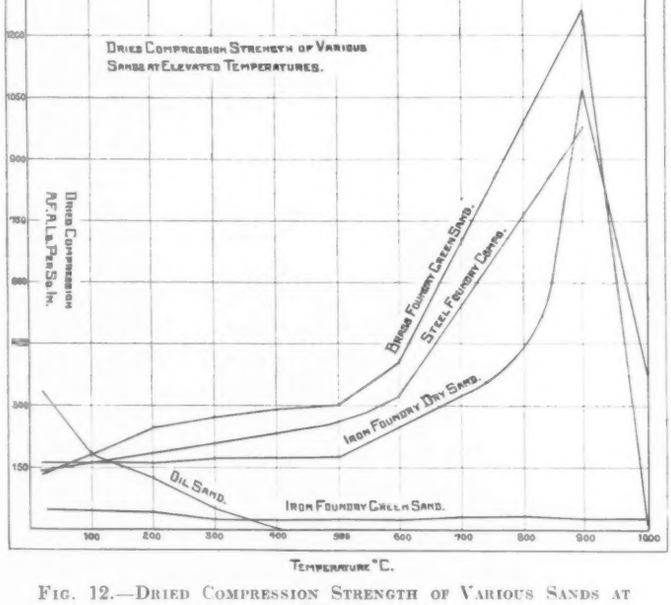
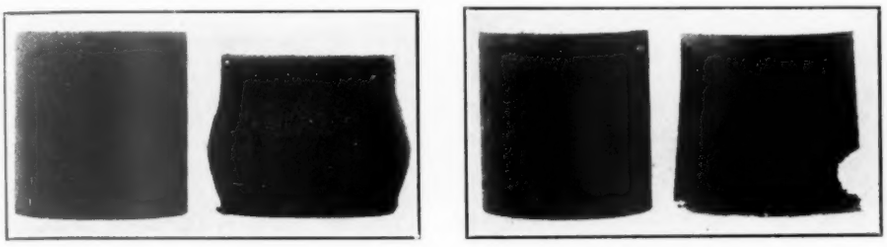


FIG. 12.—DRIED COMPRESSION STRENGTH OF VARIOUS SANDS AT ELEVATED TEMPERATURES.

It is also interesting to note from Fig. 12 the remarkable effect of coal dust on the strength of moulding sand at elevated temperatures. Observation of the values obtained on "iron-

foundry green sand" in comparison to the "brassfoundry sand" previously discussed, which does not contain coal dust, indicates that the addition of coal dust prevents softening under load at the range of temperature covered by these tests. More important still, the coal-dust addition seems to prevent the large increase in strength which occurs as the temperature of the sand rises, and the value of this fact cannot be over-estimated in its effect on casting



Figs. 13 and 14 shows that Bulging rather than Fracture occurs at High Temperature.

production. It might be wise to state at this point that this conclusion is not based on the results of the present tests alone, but has been confirmed by the author more positively in other directions.

In regard to the effect of heat on oil sand, the results obtained confirm the general opinion of foundrymen.

Conclusions

In reaching final conclusions upon the effect of elevated temperatures upon the compression strength of mould and core materials, it is necessary to couple the results with those obtained in connection with expansion. If this be done, it will be found that the sands which expand most are also most subject to increase in strength at elevated temperatures. Such a combination is particularly dangerous, and must be responsible for a large percentage of defective castings in the foundry trade to-day. There is only to be considered hot tears, cracked and distorted castings in the steel industry, cracked castings in the various branches of the iron trade, etc., to see the results of some of these previously unknown properties of mould and core materials. Furthermore, it would seem to the author that the present methods of overcoming these defects, such as "bracketing," "easing" of cores, etc., are at the best only makeshift remedies, and the proper technique of their elimination will ultimately depend upon the use of mould and core materials having suitable properties at elevated temperatures. In the production of large grey-iron castings in loam it is common practice to rely upon loam bricks as a means of relieving contraction stresses on cores. The usual mixtures employed for this purpose cannot possibly be of advantage unless the full text of this Paper be taken into consideration.

The Effect of Heat on Strength after Cooling from Elevated Temperatures

In the previous section some idea has been obtained of the effect of heat on the properties of mould and core materials such as would appertain during and immediately after the casting operation. There is still another factor which requires consideration before the conclusion of this Paper, and that is the effect of heat on the strength of mould materials after cooling from elevated temperature. Information in this direction determines to a large degree the question of fettling costs.

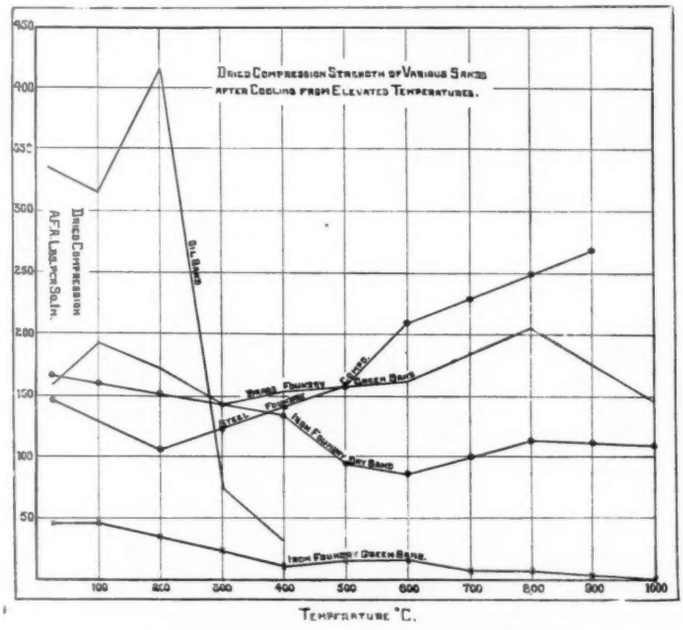

Dried Compression Strength of Various Sands after Cooling from Elevated Temperatures.
Dried Compression A.F.A. Lbs. per Sq.In.
Oil Sand
Temperature °C.

Fig. 15.—Dried Compression Strength of Various Sands after Cooling from Elevated Temperatures.

Accordingly standard A.F.A. compression test-pieces of the various sands were heated up in an electric muffle furnace to the temperatures required and allowed to cool slowly overnight in the furnace. When cold they were broken under compression, and the results obtained are shown in Fig. 15. It will be observed that the increase in strength at elevated temperatures of mould and core materials, as illustrated in Fig. 12, is not maintained after these materials have cooled to room temperature under conditions of normal foundry practice. The decrease in strength can be undoubtedly ascribed to the effects of contraction strains in the refractory material itself. Given a sufficiently slow rate of heating and cooling, extending into several days in either direction, the properties at elevated temperature would undoubtedly be maintained with the resulting production of firebrick articles such as can be observed in brick works. The results obtained in Fig. 15 are interesting, however, as they indicate that the type of mould and core materials employed, together with the temperatures reached, determines the ease or otherwise of the fettling operation. Coal dust additions seem to play a very large part in preventing the sand grains from "fritting" together, and promotes removal of the sand from the casting. It should also be observed that heat affects some sands in a different direction to others. For example, if a mould be considered as made from the steel foundry "Compo," the greater the heat on the mould the greater the difficulty in fettling, whilst the reverse holds good for "iron foundry drysand."

From the data given in this Paper one can obtain a proper appreciation of the properties of mould and core materials at elevated temperatures. The only information now necessary for the transcription of these results into practice is some idea of the existing mould temperatures arising from the casting of various sectioned metals and alloys. No work has been done in this direction by the present author, but Fig. 16 has been drawn up from experiments conducted by Dierker[5] and Maske and Piwowarsky[6], and whilst the information relative to cast iron may not be too complete, the particulars given for steel castings should definitely prove of value.

It is hoped that the results given in this Paper will prove of benefit to the foundry trade as a whole, not only in advancing the technique on a subject which has been far too long over-

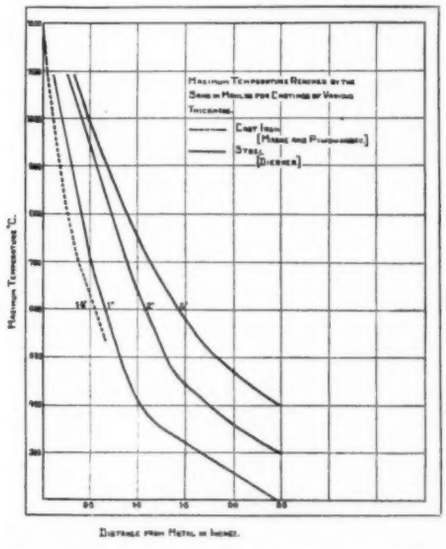

Maximum Temperature Reached by the Sand in Moulds for Castings of Various Thickness.
Cast Iron
Steel
Maximum Temperature °C.

Fig. 16.—Maximum Temperature reached by the Sand in Moulds for Castings of Various Thickness.

looked, but also in indicating new lines of research for simplifying and improving the production of castings. In presenting this Paper to the Institute, the author fully appreciates that more could have been said, particularly relative to the effect of the composition of mould and core materials on the physical properties obtained at elevated temperatures, but this omission has been more or less intentional.

D

Continued research in this latter direction has resulted in the production of some extremely interesting data, which will form the basis of another Paper at some later date. For the present it can definitely be assumed that the results embodied in this present Paper are by no means exceptional to the materials tested, but are definitely representative of existing conditions in nearly every foundry to-day. Furthermore, the main intention of this work is to outline some hitherto unknown properties of mould and core materials, properties virtually of fundamental importance, and if this has been accomplished, the main object of the Paper has been served.

In conclusion, the author desires to express his thanks to the directors of Messrs. Glenfield & Kennedy, and Mr. Henry Gardner for permission to publish these results, and also to place on record the valuable assistance given by Mr. R. F. Hudson, who was responsible for conducting many of the tests described. The author is also indebted to Mr. T. R. Walker, chief chemist of the English Steel Corporation, for his courtesy in supplying samples of steel-foundry "Compo."

APPENDIX.

In regard to the "dried compression strength" values at elevated temperature, shown in Fig. 12, it should be noted that at 1,000 deg. C. the strength of steel foundry "Compo" was 1,360 lbs. per sq. in. Similarly, in regard to Fig. 15, indicating the strength after cooling from elevated temperature, the value for steel foundry "Compo" was found to be 240 lbs. per sq. in. after cooling from 1,000 deg. C.

These further tests have been completed since the Paper went to press in view of their probable interest to steelfounders.

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3 "Temperature Affects Moulding Sand," by Sixten O. V. Nilsson. "The Foundry," March, 1933, p. 10.
4 "The Expansion and Contraction of Moulding Sand under Elevated Temperatures," by H. W. Dietert and F. Valtier. "Trans. A.F.A.," 1935. (Advance copy.)
5 "Reclaiming Steel-Foundry Sands," by A. H. Dierker, FOUNDRY TRADE JOURNAL, February 13, 1930, p. 121.
6 "The Gas Permeability of Moulding Sands" by F. Maske and E. Piwowarsky FOUNDRY TRADE JOURNAL, March 28, 1929, p. 233
7 "Some Experiments on the Refractoriness of Foundry Sands," by D. W. Trainer, Jr. "Trans. A.F.A.," Vol. 34, 1926, p. 327.

Copper in Malleable Iron

According to C. H. LORIG and C. S. SMITH, in a contribution to the "Transactions" of the American Foundrymen's Association, there is no appreciable modification of the tensile strength and yield properties of malleable iron with the addition of copper up to 0.7 per cent. The copper refines the grains and produces smaller and more numerous graphite nodules. There is also an improvement in endurance properties, while galvanising or intergranular-embrittlement susceptibility is reduced. At least 3 per cent. of copper can be taken up by iron.

Precipitation Hardening

The investigation of and present state of knowledge regarding the precipitation hardening of duralumin are discussed by G. WASSERMANN in Report No. 325 of the materials subcommittee of the Verein deutscher Eisenhüttenleute, published in "Archiv für das Eisenhüttenwesen." It is emphasised by the author that the hardening process is of such a complex nature and preceded by so many preparatory stages having a direct influence on the course of hardening that it is not reasonable to regard the problems of precipitation hardening as definitively solved, whether of steels or non-ferrous alloys. The generalisation and arbitrary nomenclature of hardening processes of this class are therefore not justified.

Pattern Plate Storage

An interesting and somewhat novel method of storing valuable pattern plates of the single-sided variety has been installed in the works of Messrs. Willey & Company, Limited, engineers, Exeter. Due to the rapid advance of machine moulding in foundries, pattern plates are of necessity required to be much more accurate than those used for hand-moulding, and damage to the plates themselves, apart from the pattern, has become an evil to be avoided, particularly in the case of plates which have to fit machines accurately to facilitate speedy changing and setting up as well as accuracy of the draw.

The racks shown provide for the horizontal storage of plates, each pair being located side by side, each in its own section. The plates slide into the rack on hard-wood replaceable

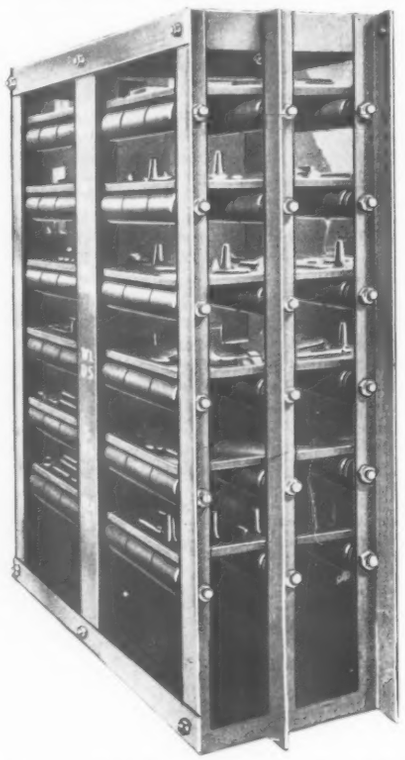

FIG. 1.—A NEW TYPE OF PATTERN PLATE RACK.

rollers, there being three lines of triple rollers each, for each pattern plate. Eight batteries of racks are at present in use, each battery designed to carry fourteen pattern plates, the total weight being approximately 11 cwts.

Since having these racks in use, the cost of pattern maintenance has appreciably diminished; also by placing the racks near the moulding machines and giving each pattern plate an identification mark, with corresponding marks on racks, much time is saved for the operator.

The racks illustrated in Fig. 1 are suitable for single-sided plates, but a simple modification of this design can be used for double-sided plates or for multiform patterns. Messrs. Willey & Company, Limited, have found them so advantageous that they have decided to market the contrivance for the benefit of the industry.

MR. W. MURRAY MORRISON, vice-chairman of the British Aluminium Company, Limited, was presented with his portrait, together with an illuminated album signed by 426 colleagues and business associates, recently. The presentation marked the completion by Mr. Murray Morrison of 40 years with the company.

Progress of Fuel Research

The Department of Scientific and Industrial Research issued on November 29 the Report of the Fuel Research Board, together with the Report by the Director of Fuel Research for the year ended March 31, 1935. The Report is made the occasion for a review of the progress achieved in the fuel industry during the 25 years of His Majesty's reign. Consideration is given to the relation between the Board's researches and the remarkable changes which are taking place in the utilisation of coal.

The coke-oven industry is closely associated with the iron and steel industries, whose coal requirements have fallen by some 15 million tons a year. A considerable proportion of this is due to reduction in the amount of pig-iron produced, but it is claimed by the British Iron and Steel Federation that since 1923, largely from the application of the results of research, £1,500,000 per annum has been saved in the cost of fuel. This figure indicates broadly that about 6 million tons less coal were necessary in 1934 than would otherwise have been the case.

The economies in the use of coal in furnaces have been secured largely by burning it in a form that enables it to be fed at a controlled rate into the combustion space. The greatly increased use of mechanical stokers and of pulverised fuel has given to coal and coke a large measure of the flexibility possessed by fluids such as oil and gas. Quite substantial advances are taking place at present in applying mechanical stokers to comparatively small coal- or coke-burning units, such as are installed for central heating.

Usage of Pulverised Fuel

The use of pulverised fuel has increased in the last five years from 2¾ million tons per annum to over 4½ million tons. The pulverised fuel report states:—

"Pulverised fuel is used for many purposes, and there has lately been a marked expansion in its application to metallurgical purposes, which include heating and reheating billets, smelting and melting, annealing and copper refining. It is of interest to record that at the end of 1933 the first plant for supplying coal ready pulverised was installed by a colliery in Yorkshire, and that pulverised coal of a standardised calorific value is now being offered from a plant in the London area for delivery in tank wagons to small consumers.

"Though these economies have the immediate result that less coal is mined, the total energy derived from coal and usefully applied was appreciably greater in 1934 than in 1910. The gain in efficiency has an important bearing on the cost of living and the cost of production of manufactured articles."

Considerable progress has been made in the improvement of burners for pulverised-fuel furnaces towards overcoming the difficulties of burning low-volatile coal, such as some South Wales coal, in furnaces with restricted combustion spaces. Two of these new burners are being manufactured by commercial firms under licence, and with one of them—the "Grid" burner—good results have been obtained in a Lancashire burner with a coal containing as little as 15 per cent. of volatile matter.

The Report is published by H.M. Stationery Office, price 3s. 6d. net.

THE SCOTTISH COURT OF SESSION has approved of the proposal of Messrs. William Baird & Company, Limited, to reduce the capital of the company from £3,100,000 to £1,985,425. The paid-up capital is £2,972,200, and there are also 127,800 ordinary shares unissued. It has been agreed that the 2,972,000 ordinary shares of £1 each should be reduced in value to 12s. 6d. each, and that the share capital should be again increased by the creation of 1,114,575 ordinary shares of £1 each.

Vitreous Enamelling Section

DEALING WITH PAPERS PRESENTED TO THE INSTITUTE OF VITREOUS ENAMELLERS

Notes on Furnaces for the Vitreous Enamelling Industry

By Th. TEISEN, B.Sc., M.Ing.F., Furnace Engineer

The science of furnace technique, although it has made great progress during the past ten to twenty years, is not by any means yet in such an exact state as other branches of engineering. To produce a desired condition of heating in a certain furnace requires as a rule certain characteristics of the flame. It may be a very high local temperature is required at one spot. It may on the other hand be the aim to distribute the temperature evenly, or again the flame itself might be either of reducing, neutral or oxidising character. Furnace design is therefore not merely the result of technique; it is still just as much an art which cannot be acquired by theory alone, but only by long practice combined with certain aptitude.

Furnaces, whatever the kind of fuel, may be divided into two main classes, those where fuel is fired direct and those using some system of preheating of the combustion air. Direct-fired furnaces, although still used, must in the light of modern practice, be considered wasteful.

The newer types of furnaces are usually designed on the recuperative or regenerative principle. The latter, already invented by Siemens in the middle of the last century, although used extensively in larger furnaces for other industries, is unsuitable for enamelling furnaces, and can therefore be omitted. The recuperative principle, on the other hand, is applicable to most of the furnaces used in enamelling works, and if designed correctly, confers great advantages on them so far as economy is concerned. Refractory recuperators may be divided into tubular and plate or tile types. The latter are generally less efficient, and modern tendency has been to go over to the tubular type.

Efficiency Factors

It may be worth while to outline the several factors on which the efficiency of a recuperator depends:—

(1) It must have a large active heating surface, and as the place in which the recuperator has to fit is generally limited, the heating surface per unit of space must be as great as possible.

(2) The wall which separates the two gases and through which the heat has to be conducted must be as thin as possible consistent with strength, and of uniform thickness, to avoid local overheating and setting up tension in the tubes, resulting in cracking.

(3) The passages themselves, especially those of the air to be heated, should be narrow, and steps should be taken to effect the most intimate contact between the heating surfaces and the gaseous fluid.

(4) It must provide for safety against leakage between the gas and air channels.

(5) In regard to practical requirements, it must be postulated that they are easy to inspect or clean, and simple to make and to erect.

To comply with these conditions the author designed a recuperator of hexagonal shape which combined the essential features outlined, and which may be built into recuperator units in a variety of ways. The hexagonal design is in itself no new idea. Indeed it is seen in nature in the form of the bee-hive, and it is well known by students of nature that it is the most economical structure in material, and it therefore ensures a smaller weight per unit of space than with any other shape—a fact which is worth taking advantage of. The smaller total weight of the recuperator tends to make regulation quicker and easier, besides saving cost. The tubes are made in various sizes, according to the temperature and coal consumption of the furnace, and a few applications are described later.

The Lencauchez has horizontal gas channels and vertical air channels; the Hermansen type mostly horizontal gas and air channels crosswise arranged, while in the author's hexagonal type the gas channels are usually arranged horizontally with vertical zig-zagging air channels or also with horizontal gas channels and horizontal zig-zagging air channels, or finally with vertical gas channels and horizontal zig-zagging air channels. The active heating surfaces work out respectively at 36 sq. cm. for the Radot-Lencauchez, 20 to 40 for the Hermansen, and 100 for the author's hexagonal type, all per cub. dcm. space occupied. The hexagonal type has thus roughly 250 to 500 per cent. more active heating surface than the other types, and, of course, compared with the various tile types the difference is even more striking.

The increase in economy effected by recuperation is due to various causes:—(1) It recovers from the waste gases a certain amount of heat units corresponding to the quantity of secondary air heated and its temperature; (2) it decreases the amount of excess air and effects a corresponding economy, and (3) it raises the flame temperature of combustion, and the increased radiation of the hotter flame effects a more efficient and quicker heat transfer with corresponding increase in economy. The result is that, as compared with direct-fired furnaces, for instance, an ordinary coal-fired furnace, a saving in fuel of the order of 30 to 50 per cent. may be obtained. But these figures apply only to furnaces having recuperators with the requisite active heating surface, and the majority of muffles of various types one comes across are grossly under-recuperated.

Unfortunately, in the case of oil-fired muffles it is difficult to take advantage of full recuperation as the ensuing flame temperature is so extremely high that it calls for the most expensive refractoriness, and even these will be attacked in a much shorter time than in the case of gas firing unless some dilution of the heat is resorted to.

Hence, direct firing or firing with only partial recuperation is mostly used in case of oil-fired muffles and they are consequently working at a lower thermal efficiency. As the cost of the oil is dearer per B.T.U. the economy is further reduced, and where conditions of space, etc., allow for gas firing it is by far the cheaper of the two for the heating of muffles.

Oil Furnaces

When the question refers to melting furnaces the aspect is different. Here one can draw full advantage from the intensively hot oil flame and allow it to develop freely over the material to be melted and impart its heat to same. Also in the case of smaller muffles, or even single muffles, it is often advantageous to select oil as fuel, as the firing is simplified, and there are, of course, also other factors such as conditions of locality and space, which make it desirable, sometimes even necessary, to use oil in spite of the other disadvantages mentioned. In that case it is very important to get a furnace of a high standard as nothing is dearer in the end than a cheaply-constructed oil furnace.

If one next considers the various kinds of gas-fired furnaces it will be found that apart from a relatively small number fired by town gas or coke-oven gas, or commercial producer gas such as Mond gas, the majority are producer-gas fired either from built-in or central (static) producers.

Where the fuel consumption is not too high and the number of furnaces limited or their location so situated that a central producer plant is not a practical proposition, the built-in producers offer an excellent and efficient means of firing. The main principle to be followed in the design of all producers is to have complete control of the primary air, admitted under the grate. Also the design of the grate itself should be suitable for the fuel in question. The older types of producers, such as the Siemens, had open grates with a fairly high fuel level and the height of this, together with the draft at which they worked, regulated the amount of gas produced. A more modern form of built-in producer is the step grate producer with water-cooled fire plates and ash pan, which has been found very suitable for many purposes.

Producer Gas Furnaces

Producers might be either steam blown or working on natural draft. The built-in producer works usually on the latter principle. The advantage of built-in producers is that the heat contained in the hot gases is not lost, these being delivered to the furnace at their maximum temperature. As the temperature of combustion depends, other factors being equal, on the temperature of the gas and air, the advantage of hot gas will be readily understood.

In the case of central producers it is therefore advisable to reduce the gas flues to reasonably short lengths by placing the producer near to the muffles to be heated. When running a producer, care should be taken to avoid the formation of clinker in the hottest zone of the fuel bed. It is for this reason that in the built-in producers the firebars are water-cooled and also the ash tray filled with water of which a certain amount evaporates and rises through the fuel bed, in the form of steam. The amount is, of course, low compared with that in a steam-blown producer where as a rule the primary air is injected by means of a steam blast. All firms interested in this form of firing are advised to discard the steam injector and use fan air with steam admixture instead. This gives less noise and steadier air blast.

The air and steam admitted under the grate of the producer effect a number of chemical reactions in the fuel bed. As is well known, carbon combines with oxygen to form carbon dioxide. Next a certain amount of the carbon dioxide is again under absorption of heat reduced to carbon monoxide. Again, there is the steam at the higher temperature zones in the producer being reduced by the hot carbon and forming carbon monoxide and hydrogen as well as carbon dioxide and hydrogen. The latter processes, being endothermic, tend to cool the fuel bed, thereby reducing the formation of clinker and also the temperature of the gas. As a com-

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pensation for these losses, the gas becomes enriched by hydrogen with its high calorific value.

When working a steam-plant producer, the temperature of the air blast is measured by a thermometer, and usually only so much steam is given as will just prevent the formation of clinker.

Modern producers have been developed to a very high standard, the coal being filled continuously by mechanical means, the top of the fuel bed being stirred in the same manner, preventing the formation of air holes, which are a source of losses, and finally the ashes being removed, also mechanically, either continuously or at required intervals. The result is that gas of high calorific value and great constancy can be produced in this manner with a minimum of attention. In some cases, for industrial-furnace heating, the gas is scrubbed and cleaned. This method of firing has its advantages in that it eliminates the weekly burning-out operations of the gas flues, but the cooling of the gases and elimination of the tar, of course, diminishes the over-all efficiency. As a stage between these two types of central producers, the more recently developed types, using coke breeze or cheap-grade anthracite, offer greater scope, as such plant can deliver gas of approximately 400 deg. C., giving practically no sooting and of good calorific value. But it is necessary to have at least, say, four muffles before the higher cost of installation can be justified. Finally, there are such methods of firing as pulverised fuel and the mechanical stoker. The former is not applicable to muffle furnaces because of the dust.

The mechanical stoker can be used, but the character of heating is mainly that of direct firing, and as the quantity fired in a muffle is relatively small, say about 1 ton per 24 hrs., it does not, in personal opinion, offer any real advantages.

Refractories

In regard to furnace construction, the most important materials are the refractory materials. Unfortunately, from the furnace engineer's point of view, the producing of high temperatures has made bigger strides than the refractoriness of the bricks themselves, although it will be admitted that great developments have taken place lately. The ordinary firebrick is an alumina-silica-clay mixture, containing certain impurities, such as iron and alkaline, which have to be kept down to give a good refractoriness. This lies normally for ordinary first-class bricks about seger cone 30 to 31, corresponding to 1,670 to 1,690 deg. C.

Besides, there are the pure silica bricks, which have a higher refractoriness, but do not withstand changes of temperature, nor certain chemical reaction, so well as the other bricks. With rising alumina content of the brick, the refractoriness is increased. What may be termed a special grade of firebrick has an alumina content of 40 to 43 per cent., and refractoriness of cone 33 to 34. For higher temperatures one has to use special refractories, such as sillimanite, the raw material of which is a natural product, almost pure mullite (1 silica, 2 alumina), a mineral found in India. The alumina content of the finished brick is approximately 60 per cent. and the refractoriness about 1,750 deg. C. For still higher temperatures, special refractories made of silicon carbide or electrically-fused alumina, have been developed, but these being extremely dear, are mostly used in combustion chambers and other places with intensely high temperatures. The refractoriness is approximately 1,800 deg. C.

Insulation

One important item in modern furnace construction is their insulation. It is only necessary to go back about 10 years to find a great many furnaces which had not a single insulation brick built into them. Now it has at last dawned on the users that it is best to insulate, although it can perhaps be said that there is a tendency now to go to the other extreme. From an economical point of view, the amount of insulation spent on a furnace depends to a great extent on the cost of the fuel. The author has in his own practice always used insulation, and most of this material used has been the Danish "Moler" bricks, which he has found satisfactory.

In the design of a furnace, no general rules can be laid down with any certainty in regard to mechanical strength. For instance, the stresses set up by expansion vary considerably, and make calculations almost useless. Nevertheless, in designing, provision must be made in one way or another for counteracting the effects of these forces. In the calculation of a furnace the different areas are determined to give certain speeds of the moving gases. Their temperature has, of course, to be estimated and allowance made for their expansion. Many other points have to be watched, such as the avoidance of impinging flame on the brickwork, or the producing of an even flow from a number of flues communicating with a single flue, and so on.

Many are the pitfalls in furnace design, and great sums have been wasted by works trying to design their own furnaces. In some cases works appear to have taken this course because of bad experiences with other types, but if the management will really take the trouble of comparing the various furnace types on the market in greater detail, and study the underlying principles, as well as really reliable performance figures, it is difficult to see how they can make mistakes. Too often this course is not taken; the matter is decided in a hurry, often on price alone, and nobody can be surprised if the best results are not obtained.

Muffles

Box Type.—This is the standard type used in this country, both for fusing, annealing and scaling operations. In such a furnace, the goods are resting on perrits inside the muffle, and heat is transferred to them mainly by radiation. This being the case, the ideal type to comply with physical laws should have the shell heated equally from top, bottom, sides and ends. This is best obtained by passing the burning gases underneath the hearth and afterwards taking them round the remaining parts in such a manner as to give a slightly progressive temperature towards the door in order to compensate for losses from this unheated end.

This principle is in the main followed in a number of designs, but there are others which differ completely; for instance, the overfired type, where the gases are led over the arch first and afterwards under the bottom, or that type which is heated by internal-combustion chambers arranged in the sides and relying to great extent on convection. Such types can never compare in efficiency with those which are designed more in line with the ideal type outlined above, although, of course, they will give service.

Another example of wrongly-applied theory is that of the V-shaped bottom Manyon type, originally introduced from America. By giving the bottom a zig-zag shape, and thus increasing the surface compared, for instance, with a flat bottom, a much greater efficiency is claimed. It might serve as a convenient form of landing brick, but, so far as increased efficiency is concerned, that is all wrong. Heat rays, as light rays, follow the cosinus law, which postulates that the radiation is at the maximum when taking place at an angle of 90 deg. to the radiating surface and decreasing to 0, when the rays are parallel to the radiation surface, with the cosinus of the angle between the rays and a perpendicular on the radiating surface.

The *Continuous Type* has made great progress, especially in the United States and on the Continent. It is most suited for large works and for a production of uniform character in regard to fusing time. There are different types—the single straight-through type, the horizontal "U" type, and the inclined "U" type. The author has had experience with all, and is strongly in favour of the single type wherever space allows its adoption. The design is much simpler, and the muffle shell more accessible.

The output of a continuous furnace designed on correct lines depends to a great extent on a suitable and light design of the baskets and perrits. Continuous furnaces can be fired in the same manner as box types; producer-gas firing has proved the most trouble-free in the author's experience. When designed properly on the counter-low principle, they are very economical.

Dryers

These can also be designed on the continuous principle, but full advantage cannot be taken of this, due to the fact that spraying and dipping is usually suspended during the night. The Batch type, therefore, has proved more suitable, and the most successful type has been the one where the goods are dried in a chamber dryer carried on small trucks of about a load's capacity. The dryer is heated by streams of hot, clean air heated in an air heater by the waste gases from the furnace.

It may be asked how an efficient recuperative muffle can have sufficient heat for that purpose. The answer is that in the waste gases there is more than twice the heat available for preheating the secondary combustion air, and consequently if one takes care of this heat, it is sufficient for drying purposes. In special cases, where some muffles may be intermittently worked, a little additional firing can be arranged to give the necessary temperature to the air.

These dryers are most efficient and dry the ware, both sheet and cast iron, in 10 to 20 min. without any rust formation. The air heater itself is of cast iron, to give a long life, and the draft is usually created by an exhaust fan, which gives a better control than a chimney, and is much cheaper.

In order that such a muffle plant with dryer can be run correctly, it is strongly recommended to equip it with the necessary control instruments for recording the temperature of the muffle and of the hot air; the draft before and after the air heater, and the energy of the fan. If these instruments are mounted neatly on a panel, it gives the management the opportunity of seeing at a glance that all is correct, and the author has found that the ordinary furnaceman takes a keener interest in its working when he has this as a guide.

Melting Furnaces

It is a personal opinion that the rotary type is now without question the leading type, and oil firing the most suitable fuel. As everything new, it has had its infancy illnesses, but it is claimed for the new improved "Fulmina-Teisen" type that this stage is now far behind it, and that it will melt frit economically and with no trouble.

DISCUSSION

MR. BALL said he was particularly interested in the new improved design of rotary enamel-melting furnace, and Mr. Teisen's figures of 1¼ hrs. for the 5-cwt. batch, or a longer period for the 7-cwt. batch. He would be interested if Mr. Teisen could give them any information of firing temperatures to obtain those performances.

MR. TEISEN said that so far as that was concerned, he could not give any exact temperature at all, because it was difficult to measure it, and manufacturers did not trouble about it, so long as they got the output. He had taken some figures. The time for 5 cwts. was 1¼ hrs., and for the 7-cwt. batch 1¾ hrs. to 1 hr. 50 min. That did not account for the difference, but it was maintained there was a better quality by doing so. He was not sufficiently a chemist to know the reason for it, but he could see that there would probably be some volatiles they were losing, and that they could get a better quality in that respect. The heating-up oil consumption was 5½ galls., and subsequently each 7-cwt. batch took

11½ galls. That worked out at 15 per cent. In regard to the other batches, the 650, he did not think there was any reason for taking the 650, except that was the batch they were accustomed to handle; the moment you reduced your batch the fuel consumption might go up a per cent. or so, but it was so good it did not matter.

Air Dryers

MR. CLEVERLEY said that in regard to the first dryer which was shown, he believed Mr. Teisen said the air was recirculated. How did he take care of the moisture, which was taken from the air, to prevent it from depositing water as it cooled down. The second dryer had side doors. What advantage did he claim for these over vertical opening doors?

MR. TEISEN said that so far as recirculating was concerned, they took care to recirculate only part. There were three or four chimneys which ejected a certain amount of the air, which would take away the moisture. In regard to side-closing muffle doors, these were to be seen at several places. The advantage was that there was no question of dirt or grit falling down on the bath. He had seen other doors moving downwards but the side doors seemed to be the simpler arrangement. The credit for the idea belonged to the management of the works. They simply stipulated that they wanted them and he designed them accordingly. On the Continent, too, he had installed side-opening doors.

MR. BALL said that Mr. Teisen had remarked that the rotary melting furnace was definitely better than the stationary type. Would Mr. Teisen mind elaborating that point, and giving any particular points in which he considered it was superior? He had heard several discussions where it had been stated definitely that the static type gave very much better output and production costs were lower.

MR. TEISEN could only say that in certainly every case where they had installed these rotary furnaces, they had discarded the other type. They were making great strides on the Continent. It was hardly possible to go into any works there where the ordinary tank type for melting was seen. It was claimed that a better enamel was made by the stirring of the rotary action, and this appeared to be quite feasible. Also, the refractories were heated over the bath and afterwards passed underneath, making it more efficient. He did not say that any ordinary box type could not be made as efficient, if it be made recuperative, but, personally, he had not had any good experience with such. If he designed a recuperative one, he would put the recuperator vertically, because in every case some batch was carried over in the recuperator and helped to destroy it. Where there was a rotary furnace, the only bricks to take care of were the lining.

MR. WILLIAMS inquired whether Mr. Teisen considered that the rotary type of furnace was more suitable than the stationary type for intermittent work, for a firm where the melting would be for a few days, and then the furnace would be shut down. Where the rotary furnace was in continual use, the linings did not wear anything like the way they were likely to wear when there was intermittent use.

MR. TEISEN said he had never installed any rotary furnace, so far, which worked continually. In some works they were only worked very intermittently, say, two or three days, because there was not sufficient demand. It seemed to him quite clear that a rotary furnace which had a thinner and a uniform thickness of lining would suffer much less from being cooled than if there was a structure with big, thick walls. Apparently the furnace which had the thinnest lining was the best in that respect. A great deal of care should be exercised in starting up not to drive them off at the speed which the different makers claimed for them. Although it was always claimed they would do the job in half an hour, yet an hour to one and a-half hours should be taken, and this would ensure a much longer life for the lining without involving the use of any more fuel.

The CHAIRMAN (Mr. W. H. Whittle) desired some information concerning the dryer. The statement had been made that one dryer would keep two muffles in operation, and would dry the work in quarter of an hour. What type of work was meant?

MR. TEISEN replied that the type of work was electrical cookers, sheet-iron and cast-iron parts. Approximately 750 cub. ft. of air was sent out from the air heater. As high a temperature as 150 to 180 deg. C. was obtained. When running a bit "slack" it was, in any case, over 120 deg. C., which was well above boiling point. The actual temperature of the dryer, which had three compartments was, of course, lower, but high enough to dry the goods in 15 to 20 min. It was, at first, intended to have more compartments to deal with the output from the muffles producing usually twelve or more loads of sheet iron and three loads of cast iron. Having regard to the fact that there the space occupied was so small the drying capacity was remarkable. Dryers could be kept at a high temperature, provided there was sufficient clean, hot air.

MR. BALL asked if Mr. Teisen had experienced any trouble with too-rapid drying.

MR. TEISEN replied in the negative. The drying room should be kept to a certain temperature. In answer to Mr. Gray, the author gave some figures about both enamelling furnaces. At 112 deg. Fah. the air absorbed 28 grains of moisture per cub ft. At 160 deg. Fah. the amount increased to 92 grains, thus showing the progressive capacity of absorbing moisture. Other figures of interest for baths were:—Output average, three baths per hour; fuel consumption, 40 lbs. of coal per bath for a prolonged period. That meant that, coal costing 20s., fuel cost came to about 4½d. per bath, a very low figure. The average life of the muffle shell (fireclay) was about two years; combustion chambers, five years; and the recuperators, over 10 years. In his own experience, there had been no replacement since 1924.

A hearty vote of thanks was accorded to the lecturer, to which he briefly responded, and the proceedings then concluded.

Continuous Vitreous Enamelling Furnaces

MR. W. MARSHALL'S lecture on "The Development of the Continuous Vitreous-Enamelling Furnace,"* when repeated before the Birmingham members of The Institute of Vitreous Enamellers, over which Mr. W. Todd presided, gave rise to an interesting discussion. It was opened by MR. J. FALLON (Smethwick), who asked what the thermal efficiency of the continuous furnace was on the average.

MR. MARSHALL replied that in this type it was approximately eight times greater than that of the batch type of furnace.

Efficiency Related to Output Cost

MR. FALLON said that he could not appreciate how such a difference could come about, in view of the established efficiency of 45 to 50 per cent. obtaining with the latest type of box furnaces. Thus he did not see how one could get eight times 45 per cent.

MR. MARSHALL remarked by way of explanation that the only way in which thermal efficiency could be proved was by the amount of ware that was produced at a standard cost, and the output was very greatly increased in the case of continuous furnaces compared with ordinary box-type furnaces.

MR. FALLON said he recognised that aspect, but he was referring to thermal efficiency in itself.

The CHAIRMAN said a written question had been handed up inquiring was there any difficulty in applying producer gas to the "U" type of furnace.

MR. MARSHALL replied that producer-gas furnaces had been in use successfully for the last two years.

Preheating and Oxidation

Another written question inquired if the preheating zone had any bad effect on sheet metal so far as oxidation was concerned, and the CHAIRMAN added a question whether distortion was a likely result also.

MR. MARSHALL said there was no ill-effect. The reason for this immunity was that in the first place the work went into the furnace absolutely dead cold, while the final temperature of the ware was not reached until it entered the fusing zone. This gradual heating up of the ware eliminated distortion. It was when they placed cold ware into the sudden heat of the furnace that trouble arose in the batch type. It also happened that in carrying off sheet-iron goods, when they were brought out of the hot furnace flat into the cold air, distortion was caused, whereas in the case of continuous furnaces the ware had time to cool down gradually. They would see from the film which he proposed to show that the heating was graduated and slowed down, so that when the men came to handle it as it came to the end of the chain they could do so with bare hands. This slow cooling was a preventive of distortion. Cast-iron ware was being treated in a similar type of furnace to those mentioned, although none was shown on the examples cited.

Grip Coats and Continuous Furnaces

MR. I. N. WHITESMITH (Birmingham) remarked that the second written question was prompted by certain observations which he made in America. Several companies, and one large concern in particular, were not employing continuous furnaces for grip coats, and their reason was that it was not desirable on account of the slow passage of the ware. Their experience was that the slow passing of the goods from the hot-heated zone, which was, practically speaking, the oxidation zone, took so long as compared with the box muffle that it caused a certain condition of oxidation to take place, and they thought that this was responsible for copper heading.

MR. MARSHALL admitted that this was so with certain types of enamel. There were certain peculiarities in enamels, and for ground-coat purposes there was much more trouble among people who manufactured their own enamels and used them for these furnaces than among makers who bought standard types of enamel; in fact, the latter did not get this trouble to any extent.

Presentation of Film

The film was then shown, and illustrated various operations and the conveyor equipment passing through the furnace, as well as showing the furnace and other installations. Subsequently MR. FALLON said he noticed that there was a series of the mottled type of sheet ware of the flat variety depicted with no centre piercing such as they termed flash backs, and so on. He wondered whether this did not indicate that the Americans found it necessary to alter their designs in order to meet one of their biggest troubles, distortion. In this connection he asked them to visualise the ordinary standard type of British cooker, with the front made from pressings, and said he had not seen anything similar to that on the screen. It caused him to wonder whether the Americans had

* FOUNDRY TRADE JOURNAL, November 7, 1935, p. 349.

decided that the chief design should suit the continuous type of muffle, and so build the front frame up in sections.

American Cooker Practice

MR. MARSHALL explained that the furnaces shown were taken three years ago, and, since then, as they all knew, the Americans were making all-steel gas and electric cookers, and fabricating the sharp edges down over the bars. It was exactly the same as in cast iron. The front was made with bolt holes drilled in, and these bolt holes were used for supporting the ware, together with hooks. They would also notice that on the conveyors were solid bars supporting the ware. The articles were now just carried along and supported by chromium-alloy hooks of about $\frac{1}{8}$ in. dia.

MR. WHITESMITH said that from his recent visit to America he found that manufacturers had no compunction about putting a complete front to the oven door with the openings pierced in. He mentioned that among the things which he had noticed in the way of fabrication was a double-type front in steel made by a rather large concern, with various chambers and openings, including a grill chamber in the oven. In one case there were various shelf chambers with a large opening, and in other cases there were two decks. These were successfully taken through continuous furnaces. Ground coats and finished goods were held in position by protruding hooks in such a manner that they tended to lean outwards from the chain, as any movement which would swing the hooks and articles inwards was likely to cause distortion. When the heat was being applied the articles were more or less revolving, and the hooks were so fixed that they took the pull. Incidentally all these American concerns were using a very well-known quality of drawing metal, no cheap sheet metal being used.

Effect of Section Thickness

MR. HALLSWORTH, inquiring about the treatment of and its result on various shapes, said they could thicken the different shapes of any article; but in firing various thicknesses of metal say 20 gauge or 18 gauge, what would be the effect on the coating of cast iron where there was a thin section with a thickened lug on the cast-iron door? Also what was the effect with particular reference to dipping. He noticed that the work was done at a very fast speed in the film, and in regard to the dipping of flat sheets, what would be the effect on some of the varying shapes they met with. In this connection Mr. Hallsworth mentioned the weird shapes cut out in English foundries, and questioned whether they were so designed as to give the minimum amount of varying thickness and the minimum amount of material.

Tendencies in American Design

MR. MARSHALL replied that in all the latest American gas and electric cookers it was a principle that the design must suit the requirements of the enameller. In cast-iron work they enamelled in continuous furnaces, and cut away all lugs; the design of the cookers being based on technical efficiency and ease in doing the job. They certainly could fire varying thicknesses of metal through these furnaces, and the reason they were able to do this was that they slowed down the chain. They could take it as an axiom that in slowing down the speed the better the heat was able to get into the work. In the States they could see various articles being fused—pots, pans, and saucepans of different sizes and gauges, which was not easily done by other methods. Mr. Whitesmith would bear him out that the American designers cut everything out which they could possibly dispense with. They would not think of enamelling cast-iron cooker doors and frames, as they are to-day in this country, in this sort of furnace.

MR. WHITESMITH thought that Mr. Hallsworth's question rather had reference to the practice in sheet-metal work. He might say that one company in America enamelled the cooker complete. The fabricated parts were welded and dipped and passed through the continuous furnace, all in one piece.

Absorption of Heat by Tackle

Replying to Mr. Fallon, who raised a question as to the gas consumption and weight of the articles shown in the film, MR. MARSHALL said he did not think that the articles varied a lot, but some were washing bowls and others included frying pans and small utensils. With the type of furnace shown there was a tremendous amount of heat taken up by the "burning" bars, which carried the work through; but these had been eliminated since then, as the furnaces in use at the time were practically two years old. They had made the "burning" equipment very much lighter, which reduced the gas consumption very considerably.

MR. FALLON observed that the method of suspension seemed rather light in the first examples, but subsequently appeared to be heavier.

MR. MARSHALL replied that there were heavy bars in one shop, for pots and pans, and some rather heavy castings, and the other ware dealt with was largely nickel-chrome.

MR. FALLON then referred to the sealing of the furnace shown on top, and inquired if there had been any trouble as to dust or anything of that nature.

MR. MARSHALL stated that there was no trouble whatever. The whole of the roof was suspended by bars from above, and was held on an iron frame with michrome bolts and nuts. While the goods travelled through the furnace it was sealed at the top and no dust could get through.

MR. FALLON asked what temperature did the conveyor reach in practice; did it become hot?

MR. MARSHALL replied that the conveyor chain was practically cool. It was outside the heating system.

MR. FALLON finally congratulated Mr. Marshall on the great deal of trouble he had taken and on the interesting way in which he had coupled the film with his talk. The pictures and talk were very good indeed.

Vote of Thanks

MR. J. W. GARDOM then proposed a hearty vote of thanks to the lecturer, and said the film certainly added greatly to the interest of the lecture. Personally he was more interested in the conveyors than anything else. He was following very closely the remarks made as to the temperature of the chain on which Mr. Fallon had commented, and also the operation of sealing up the top of the furnace against the heat losses at that point. It appeared to be effectively done, and the method employed was clearly shown above the furnace proper.

MR. A. ENGLAND (Stoke) said he had the greatest pleasure in seconding, and had been very much interested in the operations and equipment shown in the film, which had added substantially to the value of the lecture. One or two points had specially appealed to him, and he might mention that he quite agreed with slow cooling, a factor which he had been advocating for a long time. With regard to slow heating, particularly of ground coats which were mentioned, he noticed that Mr. Marshall stated that it was only certain enamels which would stand this slow heating, and those people who made their own enamels might well think about the matter. Moreover, another point which had struck him was the terrific speed at which everything was being done, and he could not help thinking that the machine was going too fast.

MR. MARSHALL in acknowledgment remarked that it had been a pleasure to talk to the Midland members on furnace work, and to show them the films dealing with enamelling plant and equipment. He wished to say that the films were not in the nature of an advertising campaign. As a matter of fact, he had arranged before he went to Manchester to lecture to have certain parts cut out, so as to avoid any ground for a suggestion of that kind; and he could assure them that the operator had been working the whole day repairing the film in consequence.

Mr. Marshall added that any further questions which members would like to ask he should be pleased to receive in writing, and would reply to the same in due course.

The lecturer then had to leave, and an informal discussion followed on various points in the lecture.

Frit-Kiln Bricks

(Concluded from facing page.)

Incipient spalling and the consequent formation of cracks near the hot surface of the bricks become filled with molten frit. Then differential expansion and contraction occur with fluctuations in temperature, and comparatively large pieces of the hot face become dislodged and are carried upwards into the frit.

Joints and Jointing

The joints often constitute the weakest part of the furnace structure so far as resistance to the molten frit is concerned. It is essential that the joints are as thin as possible, but it is equally important that the joint is a good one throughout the whole depth of the brick. Jointing cements containing considerable amounts of free silica in the form of quartz or flint have been used, the idea being that the expansion of these siliceous materials will compensate for the shrinkage of the bricks. This does not necessarily follow, as the shrinkage of the brick may take place over a considerable range of temperature, whereas the expansions of the siliceous materials are sudden and at different temperatures, depending on which form of silica is present. Better results are to be expected by the use of a highly refractory grog of an aluminous character. If this is well fired and ground sufficiently fine, it may constitute 90 to 95 per cent. of the jointing cement. To this is added 5 to 10 per cent. of a highly-plastic bentonite-ball clay mixture which has been deflocculated with a little sodium silicate, if necessary. The whole should be well mixed so as to get even distribution of this plastic bond over the surfaces of the grog.

Summing up the various factors which influence the durability of frit-kiln bricks, we have the following:—(1) The bricks should not contain free silica, as this renders them sensitive to thermal shock. (2) An aluminous type of brick is less liable to fracture due to sudden fluctuations of temperature. It should, however, be free from contraction fissures, cracks and voids. (3) Bricks which have been fired to incipient vitrification so as to get a product which is as dense as possible give best service, provided that:—(*a*) After-contraction is negligible; (*b*) they are free from spalling tendency; and (*c*) faces of bricks are true to shape so that thin joints are possible. (4) Care is necessary in mixing the frit batch so as to secure even distribution of the components. (5) Attention should be paid by the user to prevent any unnecessary sudden heating and cooling of the brickwork. (6) A preliminary "seasoning" of a new lining is advisable. (7) More attention should be paid to the jointing material. A material of high grog content is to be preferred, provided that the grains are small enough to produce a thin joint.

Thomas Firth & John Brown, Limited

At extraordinary meetings of shareholders of Messrs. Thomas Firth & John Brown, Limited, held last week at Sheffield, sanction was given the directors' proposals to increase the capital of the company from £2,450,000 to £2,550,000 by the creation of an additional 100,000 "A" ordinary shares of £1 each for the purpose of meeting expenditure upon works extensions rendered necessary by an increased volume of business and for the general purposes of the company. It was stated that arrangements had been made for the subscription of the additional shares at a substantial premium.

Frit-Kiln Bricks

By W. HUGILL, M.Met., F.R.M.S.

The Institute of Vitreous Enamellers has recently had read to it a lecture describing the merits and operations of the various types of frit kilns. In the discussion which followed it would appear that there is marked variation in the durability of frit-kiln refractories. It is the purpose of the present lecture to review some of the factors which affect the life of frit-kiln bricks.

These factors can be divided into two main groups. First, those which occur during the manufacture of the bricks, and, secondly, those which take place during service. In the first section there are such properties as suitable chemical composition, freedom from ferruginous matter, and a refractoriness which is high enough for the purpose.

Much free quartz is detrimental, because this substance has a sharply-defined critical temperature at 575 deg. C., with a consequent volume increase of 0.86 per cent. Also, it slowly changes by solution and recrystallisation to cristobalite, with a further increase in volume, and the cristobalite formed has a critical temperature at 200 to 275 deg. C., at which a sudden volume change of 2.8 per cent. occurs. In making the bricks, considerable care and attention is necessary to prevent flaws, laminations and other obvious weaknesses in structure, such as cracks and voids. A high grog content, provided that the grog has been previously well fired, helps to prevent many structural defects. It is essential, however, that the grog is well graded and of angular fragments, so as to pack closely together and that the plastic clay is evenly distributed over the surface of the grog grains. Further, the grog and clay should be of the same chemical composition, so as to maintain a uniformly dense texture. Clays which possess a long range of vitrification are suitable, because there is less danger of over-firing them, with consequent loss of shape.

FIG. 1.—SECTION THROUGH THE JUNCTION BETWEEN A SILLIMANITE BRICK AND FRIT. THIS SHOWS THE FORMATION OF CORUNDUM CRYSTALS IN THE PENETRATION ZONE. × 100. ORDINARY LIGHT.

Firing

The bricks should be fired to such a temperature that after-contraction is practically eliminated and a dense structure obtained. They should be given a good soaking at the highest temperature, followed by slow cooling, so that the maximum recrystallisation is obtained. The external shape, size and appearance of the bricks are other cares of the manufacturer. Arch bricks, fitted together to form the melting hearth, give a floor in which any one brick is not readily "floated" when the frit gets under it.

Bricks which are regular in size, and of good shape, allow thin joints to be made. If these joints are well made and suitable material used, then the whole offers considerable resistance to the molten frit. Further, under service conditions the bricks are subjected to various influences which affect their life. Although these influences may possibly occur simultaneously, it is more convenient to consider each one separately.

It must be remembered that in service the brickwork is covered with a thin layer of glass, and this has a different coefficient of thermal expansion from that of the brick. Hence, with fluctuations in temperature, chipping and peeling may occur, and portions of the brick will be brought off along with the glass.

A brick which has been fired to such a temperature that it is very dense and highly vitrified is very sensitive to thermal shock. Therefore, temperature fluctuations are liable to cause spalling by the introduction of severe strains in the brickwork.

FIG. 2.—SECTION THROUGH JUNCTION BETWEEN AN ALUMINOUS BRICK AND FRIT, SHOWING THE FORMATION OF MULLITE CRYSTALS IN THE PENETRATION ZONE. × 100. ORDINARY LIGHT.

Corrosion

The batch is of very different chemical composition from that of the bricks, and, furthermore, it contains components such as borax, sodium, silica fluoride, and oxide of lead, which have marked fluxing action on the brick structure. That is to say, these substances melt at low temperatures and tend to form solutions with the bricks, which are very mobile at furnace temperatures. The resulting melt, therefore, readily flows away, and thus presents fresh surfaces for further attack. This is referred to as corrosion.

It is necessary, therefore, that close attention be paid to the even distribution of these fluxing constituents throughout the remainder of the batch. They can then more readily exert their action on the remainder of the batch constituents in preference to the brick. No marked concentration of these fluxes in lumps or clots should come in contact with the hot brickwork, thus preventing the formation of pockets. Also, borax contains about 43 per cent. of its weight of water of crystallisation, and the evolution of this can rapidly chill bricks with which it comes in contact.

Penetration

The surface of the hearth is penetrated to a greater or less depth by the molten frit. Under suitable conditions firebricks and more aluminous materials tend to develop a layer of crystals in this penetration zone (see Figs. 1 and 2). These crystals, by their relative insolubility (since they have already crystallised from the products of interaction between frit and brick), exert a retarding influence on further penetration of the melt. Hence operating conditions which favour the formation of this layer are conducive to an increased life of the lining. This "seasoning" can be obtained by slowly heating the lining with its attached film of frit, and then slowly decreasing the temperature to about 800 deg. C. A similar method of preserving the brickwork of newly-lined furnaces is regularly practised by individual firms in other industries, *e.g.*, steel and glass works.

FIG. 3.—SECTION THROUGH THE JUNCTION BETWEEN AN ALUMINOUS BRICK AND FRIT. THIS SHOWS GRAINS OF BRICK FLOATING AWAY FROM THE ATTACKED SURFACE. × 100. ORDINARY LIGHT.

Flotation

On examining sections of bricks after use, it is seldom that one finds a penetration layer which contains these crystals. Usually, solution of the brick matrix has occurred, and the more resistant portions, such as dense grog particles, quartz grains, etc., are removed by flotation, as shown in Fig. 3. That is to say, they are set free by solution of the matrix around them and then float up into the molten frit.

(*Concluded on facing page.*)

Settling and Anti-Settling Properties of Clays

By F. H. CLEWS, M.Sc., A.I.C.

Stoke's Law

When a finely-ground insoluble powder is thoroughly shaken up in water or other liquid, each particle tends to fall through the liquid (if it is the more dense) under the action of gravity at an accelerating rate, until eventually a steady rate of fall is reached. This uniform rate of settling is given by the well-known Stoke's Law.

$$v = \frac{2}{9} \frac{(\rho - \rho_1)\, g r^2}{\eta}$$

where ρ and ρ_1 are the density of the solid particles and of the liquid, η is the viscosity of the liquid, r is the radius of the particle (assumed to be a sphere), and g is the gravitational constant.

Thus, the denser the particle the greater its rate of settling, the greater its dimensions the quicker will be its speed of fall, and the more viscous the medium the more slowly will the particle drop. This is fully in accord with experience.

If, however, the size of the particle is extremely small, surprisingly low settling rates are obtained, so that for practical purposes such particles may be considered as almost indefinitely suspended in the liquid. The following Table I indicates approximately the settling rate in water at 20 deg. C. for particles of a specific gravity of 2.5 with the diameters shown.

TABLE I.—*Rate of Sedimentation.*

Diameter.	Velocity of sedimentation.
$\frac{1}{5}$ mm.	3.3 cm. per sec.
$\frac{1}{50}$ mm.	3.332×10^{-2} cm. per sec. or 120 cm. per hr.
$\frac{1}{500}$ mm.	$3{\cdot}33 \times 10^{-4}$ cm. per sec. or 1.2 cm. per hr.
$\frac{1}{5000}$ mm.	3.33×10^{-6} cm. per sec. or 1.2 cm. in 4 days.

It will be seen how great is the influence of the size of the particle and how close to permanence would be a suspension composed of particles of 1/5,000 mm. dia. Grains of this size are still sufficiently large to be visible under the microscope, and still smaller ones of greater permanence will cause opalescence or turbidity when dispersed in a liquid.

The Grain-Size of Clays

The size of the particles obtained when clays are thoroughly broken down by prolonged agitation in water covers a wide range. A considerable proportion are so large as usually to settle out from a dilute suspension in a few minutes, leaving a much smaller proportion, which render the liquid turbid for a long period owing to their extremely fine state of division. The range of sizes of grain found in different types of clay varies considerably. The following figures, from C. E. Marshall[1], may illustrate this in regard to the fine fraction.

TABLE II.—*Range of Grain Sizes of Clay.*

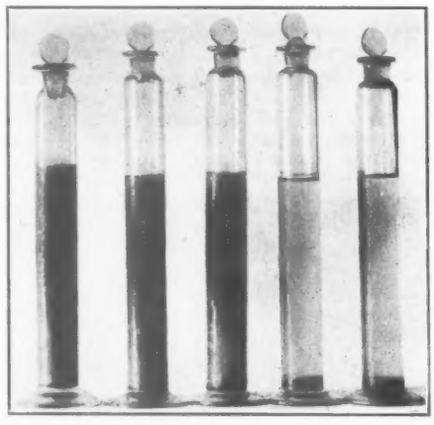
Clay.	2 μ–1 μ.	1 μ–0.5 μ.	500–200 mμ.	200–100 mμ.	100–50 mμ.	50 mμ.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Kaolin ..	66.0	21.0	7.0	6.0	—	—
Bentonite ..	2.0	31.0	16.0	12.0	39.0	
Putnam clay	7.8	6.6	11.8	11.6	21.3	40.9
Rothamsted ..	15.2	12.1	18.7	14.3	10.3	29.4

$\mu = 0.001$ mm. m$\mu = 0.000001$ mm.

Particles of this order of magnitude are generally regarded as being of colloidal dimensions, *i.e.*, in suspension in water or other liquid they exhibit special properties not shown by larger particles or shown to a much smaller extent. For instance, the particles generally develop a positive or negative charge of electricity, so that they migrate in an electric field (clays are usually negatively charged); they exhibit a vigorous Brownian movement and settle out with extreme slowness; and they are susceptible to the action of small amounts of electrolytes.

Flocculation and De-Flocculation of Clays

The action of electrolytes—acids, alkalis and soluble salts—has an important bearing on the settling properties of clays. For example, when a small amount of sodium carbonate of the order of 0.3 per cent. of the weight of the clay is added to a clay suspension, the effect is usually to increase the ability of the clay particles to remain suspended. This change is correlated with the increase in the charge on the clay particles and their simultaneous breakdown into smaller units. The process is called deflocculation or peptisation. The converse change is brought about by the addition of small amounts of acid. It involves the reduction in the charge on the clay particles, which are then more prone to unite in larger groups and aggregates, and as a consequence they settle with comparative rapidity (see Fig. 1). Starting on the left, the cylinders show the effect on the settling after a period of 30 min., of additions respectively of 0, 0.1, 0.2, 0.3 and 0.5 per cent. by weight of hydrochloric acid to a dilute clay suspension. This change—flocculation or coagulation—reaches its maximum when the negative charge on the clay particles becomes reduced to zero.



1 2 3 4 5

FIG. 1.

It is thus evident that the particle size and as a consequence the rate of settling is largely dependent on the degree of acidity or alkalinity of the aqueous medium in which the clay is suspended. Fig. 2, reproduced from F. P. Hall[2], illustrates the above statements. Of course, each clay has an acidity or alkalinity natural to it, and responds somewhat differently to the action of acids or alkalis. The presence of soluble salts also has a profoundly modifying effect. The data in Table III are also due to F. P. Hall[2].

The process of coagulation can be followed under the microscope. In the neutral or alkaline condition the particles of visible size can be seen in vigorous motion, but the addition of acid causes the particles to collect in loose aggregates which enclose water. These larger units, despite their content of water which will reduce their combined specific gravity, will nevertheless settle far more rapidly, as can be seen by applying Stoke's Law.

Coagulation of clays in suspension also carries with it certain concomitant changes in the condition of the clay-water system. For example, the suspension of slip stiffens considerably—this is noticed more particularly when there is not too great an excess of water, say one part of clay to two parts of water. Fig. 3, due to H. G. Schurecht[3], will illustrate this clearly. In passing, it should be mentioned that it is not strictly correct to talk of the viscosity of a clay slip, although in the flocculated condition it is undoubtedly more difficult to cause it to flow. This will be referred to later.

So far coagulation and deflocculation have been represented as being due to the action of acids and alkalis respectively. While the effects that increase in the H^+ ion (acid addition) or increase in the $(OH)'$ ion (alkali addition) produce are perhaps the most striking, they are not limited to the action of these substances. Many other electrolytes, and particularly salts, can cause coagulation and deflocculation. Some, indeed, may induce deflocculation when added in small amount, but coagulation when larger proportions are added. This is true of sodium carbonate, for example. The effects also may be very different for different clays, due not only to the varying colloidal condition of different types of clay, but owing to their greater or less contamination with soluble salts in the natural condition. These latter may profoundly modify the action of further additions. The following salts have been classed as coagulants:—Calcium sulphate, magnesium sulphate, aluminium chloride, ferric chloride, etc. The following have been classed as deflocculants:—Borax, potassium and sodium phosphates, microcosmic salt, sodium and ammonium oxalate, and a host of other soluble salts. At different concentrations they may cause coagulation.

TABLE III.—p_H *Data for Various Clays.*

	p_H of water of extraction.	p_H at iso electric point.	p_H at point of maximum deflocculation.
English ball clay ..	5.50	2.78	10.96
Tennessee ball clay	3.80	3.63	12.01
Kentucky ball clay	5.50	2.28	11.97
English china clay..	5.80	3.63	11.60
South Carolina china clay	4.80	3.99	10.32

Another class of substances is sometimes spoken of as deflocculants, although possibly they may be more properly regarded as stabilisers of the deflocculated condition. As examples may be mentioned humic acid, gallic and tannic acid, and silicic acid (derived from hydrolysis of sodium silicate). It might be thought that the acid character of these substances will militate against any process tending towards deflocculation. However, it appears that they form loose colloidal complexes with the clay particles which are not so easily affected by coagulating additions. In any case, being such weak acids, they introduce very little H^+ ion into the system. In support of this conception is the fact that, when added in the form of their sodium salts, they are far more effective deflocculants[4]. These salts have an alkaline reaction, and thus increase the $(OH)'$ concentration in the solution; at the same time, the free acid liberated by hydrolysis can combine with

and stabilise the clay particles. This type of protective action is well known in colloid chemistry.

Modern Conception of Colloidal Character of Clay

The impression conveyed by the early literature on this subject is that clays are composed of extremely small negatively-charged active colloid particles covering the surface of larger inert particles. One of the difficulties in this theory is that of deciding at what size or condition the particles become colloidal and acquire an electric charge.

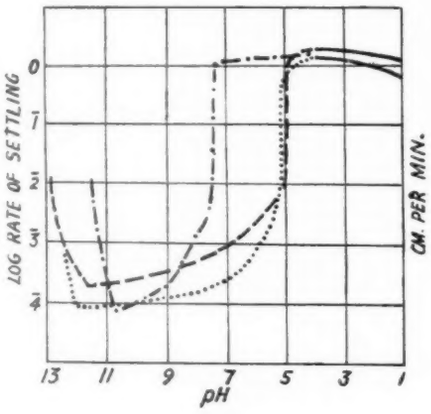


FIG. 2.

The following is a very brief account of a Paper by W. W. Meyer[2], in which he has collated and summarised modern views and proposed a conception based mainly on the views of Mattson[5]. According to Meyer, clay particles are formed by the partial or complete combination of weak acids and weak bases, the ratio of combination depending on the p_H value of the surrounding medium. Basic and acid residues occur at the particle surfaces, and can dissociate to form an "atmosphere" of ions (termed the micellar ion atmosphere), leaving ionic charges on the particles. The degree of ionisation of these groups is controlled by the concentration of like ions in the surrounding solution. The nature and number of the micellar ions influence various properties of clay.

The colloidal properties of a clay are thus made dependent on the amount of active surface which it may have. The surface activity is not only dependent on the degree of subdivision;

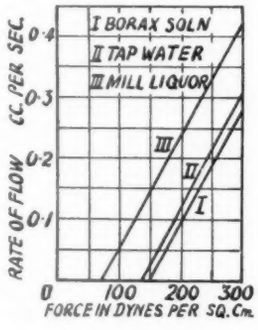


FIG. 5.

it depends ultimately on its composition. An increase in the ratio of acidic to amphoteric constituents (SiO_2 to R_2O_3), or substitution of Fe_2O_3 for Al_2O_3, or humic acid increases activity. In Fig. 4 is given a schematic representation of a clay particle.

Clay Particle.—A core composed of one or more molecules and carrying on its surface basic and acidic groups or atoms or positive or negative ionic charges, or both. (1) and (2).

Micellar Ion Atmosphere.—An atmosphere of adsorbed or unadsorbed ions surrounding the particle. (3).

Micelle.—(1) and (2) and (3).

Intermicellar Ions.—Ions in solution outside the zone (3). (−) and (+) in zone 4.

Colloid Complex.—The active particle surface, together with its micellar ion atmosphere and imbibed water. (2) and (3).

Acidic Constituents.—Those integral components of the particle which ordinarily have a negative ionic charge when ionised (the acid radicles of weak acids (A), *e.g.*, silicic-acid residues, humic acid, etc.).

Amphoteric Constituents.—Those integral components of the particle which ordinarily have a positive charge when ionised, but can have a negative charge (B).

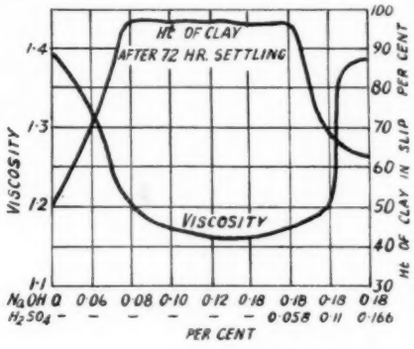


FIG. 3.

Ionic Charges (on the particle surface).—Positive and negative charges at the particle surface resulting from ionisation of acidic and basic residues or their reaction products (+ and − zone 2).

Adsorbed Atoms or Groups.—Basic and acidic atoms or groups held on the surface of the clay particle by valence bond. 0 in zone 2.

Adsorbed Ions.—Those ions held in the atmosphere about the clay particle by opposite ionic charges on the particle surface (⊕ and ⊖ in zone 3).

Unadsorbed Micellar Ions.—Ions in the micellar atmosphere not held by opposite ionic charges on the particle surface ((+) and (−) in zone 3).

Silica: Sesquioxide Ratio.—A term commonly used to express the ratio of acidic to amphoteric constituents or the acidoid to ampholytoid ratio of soil and clay colloids. Silicic acid and aluminium and ferric hydroxide are chief reactants.

This picture of the clay particle has been useful in correlating such technical properties of clay as plasticity, shrinkage, base exchange capacity and the like. In the present connection the application to flocculation and deflocculation is perhaps of greatest interest.

According to the present theory, the clay particle has a negative net ionic charge, increasing from just above the isoelectric p_H (at which net charge is zero) to a maximum at the p_H of maximum deflocculation. This negative charge is due to increased dissociation of adsorbed basic atoms or groups and the decreased dissociation of adsorbed acidic groups. But for every negative ionic charge on the particle there is a positive charge on a cation in the micellar atmosphere which collectively neutralise each other. It is reasonable to suppose that two such micelles approaching each other in suspension would be repelled by the like net ionic charges of the particles, and their atmosphere, but would be attracted by unlike net ionic charges.

The presence of a maximum negative charge on the clay particle entails the maximum number of positive ions in the surrounding micellar atmosphere, and this in turn also causes the presence of a maximum layer of water attached to the clay particle. In this state of maximum deflocculation it is considered that these water layers are thick enough to prevent molecular inter-attraction. In the coagulated condition the layer of imbibed water is thin, and hence clay particles are close enough to attract each other molecularly. It is also thought that polyvalent ions may act as links between particles.

Application to Casting Slips and Enamel Suspensions

Returning to the effects of coagulants and deflocculators on the consistency of clay slips, it

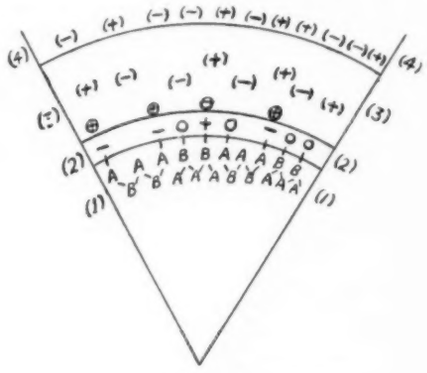


FIG. 4.

may be of interest to contrast the practice usually followed in respect of pottery casting slips on the one hand and glazes and enamels on the other.

In the case of pottery casting slips, which contain an amount of clay of the order of 50 per cent. of the total solids present, it is customary to add small amounts of sodium carbonate and sodium silicate (say 0.3 per cent.), so that the clay is in the deflocculated condition, and has approximately a maximum fluidity for a given content of water. It is thus possible to use a much smaller proportion of water than would be the case if the clay were not deflocculated. This carries with it in turn several advantages: (*a*) The clay does not contract so much on drying with a reduction in the tendency to crack; (*b*) the plaster mould is not required to absorb so much water; and (*c*) the non-plastic particles can be maintained in suspension.

In the case of enamel suspensions, particularly those used for dipping, the case is different,

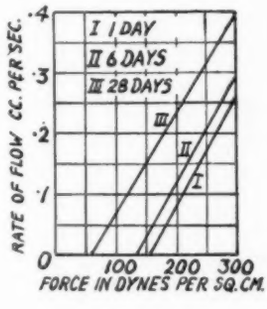


FIG. 6.

and is tackled differently. The percentage of plastic clay is considerably lower, say 5 or 6 per cent., and the non-plastic constituents may have higher specific gravities than the clay. While, therefore, the effect of deflocculants would be to enable the clay particles to remain suspended, it would tend to allow the non-plastic part to settle out. It is usual on this account to add coagulants in the form of borax, magnesium sulphate, or acids to the mill batch.

so that the fluidity is decreased, and while the enamel as a whole can settle more quickly, there is less separation of the different constituents.

It will thus be evident that the character, and concentration of the soluble salts or electrolytes in an enamel suspension will appreciably modify its consistency, mainly through the medium of their action on the clay present.[5] To some extent also the fine milled frit will also develop colloidal properties, and in so far as this occurs will the enamel be increasingly susceptible to the action of electrolytes. W. N. Harrison[6] has shown that the frit particles acquire a negative charge, as does the clay.

Consistency of Enamel Slips

The consistency of an enamel slip is conveniently judged by a simple apparatus, consisting merely of a burette with the lower end cut off and replaced by a rubber bung carrying a capillary tube of convenient length and bore, say 12 cm. long and 0.16 cm. dia. The slip is then poured in and the time for successive 5 c.c. of slip to run out is obtained with a stop watch.

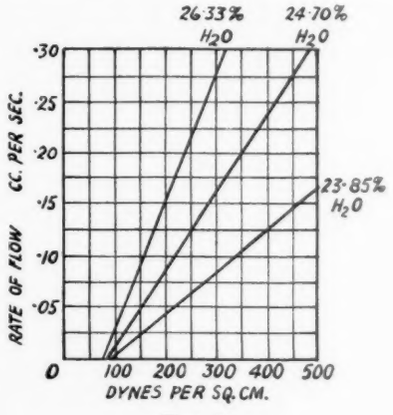


FIG. 7.

In this way the rate of flow of the slip under different decreasing heads is obtained. This rate of flow is then plotted against the stress producing it, which is given by the expression

$$\text{Shearing stress} = \frac{R h D g}{2l}$$

where R = radius of capillary (cm).
l = length of capillary (cm).
D = density of slip.
h = average height of slip during a timed period.
g = gravity constant.

The usual result is a series of points on a straight line, which should be produced to intersect the stress axis. The important data yielded by such a line are (1) its slope, *i.e.*, rate of flow / stress, and (2) the intercept it makes on the stress axis, *i.e.*, the theoretical force is required to start the slip flowing. A curve of this sort is characteristic of a plastic solid rather than a liquid, and it is somewhat surprising that enamel slips conform to it. With a liquid, even a viscous one, a series of points lying on a straight line would be obtained, but the line would pass through the origin. In other words, a liquid would deform or flow under the slightest force if maintained long enough. With plastic solids, more than a minimum force is required to start the flow.

In connection with enamels, the slope of the line representing the mobility of the slip is related to the ease of working. The more mobile enamel drains more easily on the ware. The intercept on the stress axis—termed the yield value—is related to the thickness of the coating of enamel which is obtained.

Numerous experiments could be adduced which show the effects of various salt additions on the mobility and the yield value of the enamel. It seems reasonable further to relate these results to the effect of the salts on the colloid material, particularly the clay, which is present. For example, a number of instances may be quoted from a Paper by W. N. Harrison[6]. Fig. 5 indicates the different yield values obtained with an enamel slip when made up (*a*) with the mill liquor, (*b*) with tap water, and (*c*) in the presence of 1.5 per cent. borax. The mobility is hardly affected. Direct sedimentation tests showed that the borax caused flocculation of the frit.

R. D. Cooke[7] has stated that the following salts increased the yield value of an enamel considerably without changing the mobility:—Borax, aluminium chloride and cobalt nitrate (these are usually considered coagulants). The following increased the yield value slightly without changing the mobility, sodium chloride, sodium carbonate, sodium acetate, sodium thiosulphate, ammonium chloride, ammonium carbonate (some of these may act as clay deflocculants and some as weak coagulants). The following increased the yield value enormously, and also reduced the mobility:—Magnesium sulphate, barium chloride and calcium chloride (these are typical coagulants). Sodium silicate (a deflocculant) reduced the yield value considerably, and also the mobility. This list cannot be applied generally, because the results obtained depend on the amount of the addition and the nature of the enamel, and in particular the composition of the mill liquor. However, it indicates the general trend of coagulants to increase the yield value of the enamel suspension.

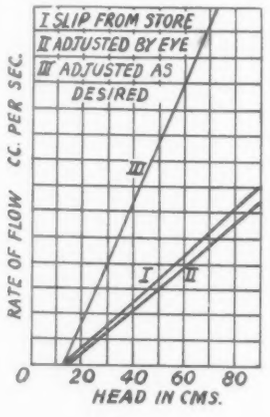


FIG. 8.

It is also probable that the well-known changes in the consistency which occur when enamel slips are aged are connected with changes in the salt content of the aqueous medium. There is a slight solvent action of the water on the ground frit which, continuing for days, may materially increase the concentration of salts in solution, and thereby the consistency of the enamel. Thus, L. D. Felterolf[8] has attributed the gradual decrease in yield value and the increase in mobility of a glaze on ageing to a gradual increase in alkalinity of the aqueous medium. W. N. Harrison[6] also reported similar changes in an enamel (see Fig. 6). Significant changes in the consistency of an enamel may be caused by variations in the hardness or salt content of the water used.[9]

In addition to the action of electrolytes, it is also evident that an alteration in the consistency of an enamel can also be brought about by controlling the water content. Increase in the amount of water usually reduces the yield value and increases the mobility. This will be evident from Fig. 7, due to R. D. Cooke[7]. It is thus clear that, by altering the salt content and the water content, within limits it may be possible to adjust the consistency so that the working properties, as judged by the yield value and the mobility, conform to a desired standard. By this method W. N. Harrison[6] has illustrated how it is possible to eliminate a fault of waviness which the foreman, operating by eye alone, was unable to do (see Fig. 8).

Summary

(1) The rate of settling of solids in liquids is dependent on the size of the particles. Particles which are so minute as to settle with extreme slowness are in, or bordering on, the colloidal state.

(2) Particles of such size are sensitive to the presence of electrolytes, which can affect the dimensions of the particles, and thus their rate of settling. Clays come into this category.

(3) The action of electrolytes on clay slips also affects their readiness to flow.

(4) In an analogous manner the consistency of enamel slips is related to the effect of electrolytes on the colloidal content of the slip. The clay is probably the most active part of this colloid fraction.

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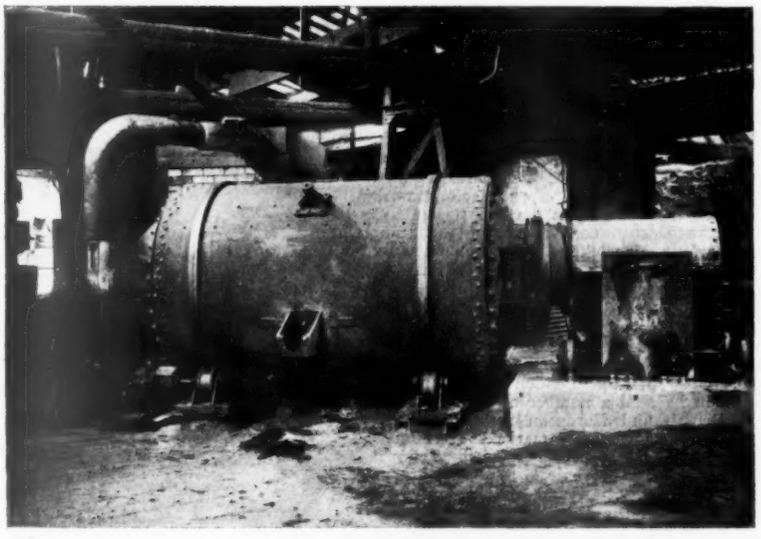
Catalogues Received

Air Heater Units. A folder received from Messrs. James Keith & Blackman Company, Limited, 27, Farringdon Avenue, London, E.C.4, deals with KB units for suspension from roof members. It calls attention to Catalogue V 145, which is probably more suited to our readers.

Saw Set. A three-leaf folder, issued by Messrs. James Neill & Company (Sheffield), Limited, Napier Street, Sheffield, describes and illustrates a neat tool (No. 77 direct reading) for setting saws. It has many advantages over most of the foreign variety found on the British market.

Ventilating Fans. A folder received from James Keith & Blackman Company, Limited, 27, Farringdon Avenue, London, E.C.4, deals with ventilating fans in a friendly sort of way. It is meant more for the workshop than the factory manager, but there is one phrase to which we would call attention: "If you have foundries, furnace shops, engine rooms or other sections in which great heat is generated by manufacturing processes, install Blackman fans to counteract the effect of the hot blasts on the men engaged." We have only found this application so far in works with an American "flavour" about them, but it is worth while considering.

THE ANNUAL CHEMICAL DINNER will be held in the Wharncliffe Rooms, Great Central Hotel, Marylebone, N.W.1, on Tuesday, December 17, 1935, at 7.30 p.m. Dancing will follow dinner from about 9.30 p.m. till midnight. This event, which grows in popularity among all interested in chemistry, is not sponsored by any individual society. Members and students of the Chemical Society, Institute of Chemistry, Society of Chemical Industry, Society of Public Analysts, Faraday Society, Biochemical Society, Society of Dyers and Colourists, Ceramic Society, Institution of Chemical Engineers, Institution of Petroleum Technologists, Oil and Colour Chemists' Association, Association of British Chemical Manufacturers, British Association of Chemists, and the Chemical Club can obtain tickets at 12s. 6d. each for lady or gentleman, including gratuities but not wines, from Mr. F. A. Greene, the Chemical Club, 2, Whitehall Court, London, S.W.1.



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This Week's News in Brief

Trade Talk

THE ANNUAL STAFF DINNER of the Suffolk Iron Foundry (1920), Limited, was held at the King's Head, Stowmarket, last Friday. Mr. L. J. Tibbenham (managing director) was in the chair.

TYNESIDE INDUSTRIAL DEVELOPMENT BOARD has prepared a series of informative folders dealing with sites, labour, markets, transport, and public services in the area, for the information of industrialists, whose inquiries will be welcomed at Carliol House, Newcastle-upon-Tyne.

THE WORKS OF THE Sheepbridge Stokes Centrifugal Castings Company, Limited, was visited last week by Chesterfield Rotarians, who enjoyed an interesting tour through the various shops; the melting furnaces and the centrifugal casting machines merited special attention.

OFFICIALS SENT OUT by the Singer Company, Clydebank, to the new factory at Monza, Italy, have been transferred to the factory near Paris, leaving native supervisors in charge at Monza. Joiners at the Clydebank factory have been working overnight in turns, packing machinery and other equipment for the Monza factory, the last shipment for which left on November 30.

A WORLD-WIDE WIRELESS CONFERENCE was carried out by International Combustion, Limited, between the London headquarters and overseas representatives. The London office spoke to Brisbane, Sydney and Perth, in Australia; Johannesburg, Capetown and Bulawayo, in South Africa; Calcutta and Bombay, in India; Wellington, in New Zealand; Buenos Aires, in South America; and also New York, Paris and Derby. Employees at the Derby works were able to listen in to this conference.

THE "ACHEMA VIII" exhibition of chemical plant, organised by the Dechema Deutsche Gesellschaft für chemisches Apparatewesen E.V. (German Chemical Plant Association), will be held in Frankfurt a. Main early in September, 1937, together with the 50th general meeting of the Verein Deutscher Chemiker. Frankfurt a. Main is not only suitable by reason of its geographical and economic position, but also because it was there that the Verein Deutscher Chemiker was founded in 1887.

THE EIGHTY-SEVENTH ANNIVERSARY DINNER of the Royal Metal Trades' Pension and Benevolent Society was held at the May Fair Hotel last Thursday. Captain N. A. Dore, chairman of the Board of Management, presided, in the absence through illness of the chairman, Mr. V. Jobson. Those present included the following personalities prominent in the foundry industry:—Sir William Firth, Mr. P. [illegible] Donald, Mr. J. R. Handforth, Mr. Sidney Harvey, Mr. H. Shillitoe, Mr. V. C. Faulkner (Editor of THE FOUNDRY TRADE JOURNAL), Captain J. G. Bennett and Mr. K. P. Strohmenger.

ABOUT A YEAR AGO an announcement was made concerning the proposed merger of a number of concerns in the Scottish light-castings industry. It is now stated that negotiations are on the verge of completion for the formation of the new combine, which will comprise about a dozen firms. Three of these are in Falkirk and district—the Camelon Iron Company, Limited, Grangemouth Iron Company, Limited, and Watson, Gow & Company, Limited. Other foundries concerned are located in the West of Scotland; the Lion Foundry Company, Limited, however, is not included. All the firms are unassociated with Allied Ironfounders, Limited.

THE HALLEY MOTOR WORKS at Yoker, Glasgow, have been acquired for extension purposes by Messrs. Albion Motors, Limited, who, in turn, have sold the goodwill of the former business to George Cohen, Sons & Company, Limited, the well-known engineers and machinery merchants. Halley Motors supplied the first mechanically-propelled fire engine to the Glasgow Corporation in 1910, and, by a coincidence, the last vehicle to be completed in the works was a fire engine for the Clydebank Fire Brigade. The business was started in 1901 by George Halley, one of the earliest pioneers of commercial motor manufacture. During the war an immense number of Halley lorries was employed in the mechanical transport units of the British Expeditionary Force.

A LIGHTNING STRIKE of 200 moulders at the Werneth foundry of Platt Bros., Oldham, textile machinists, which, it was feared, might have led to a cessation of work for several thousand workpeople, was happily settled after the strikers had been addressed by the secretary of the Amalgamated Moulders' Union. The workpeople resumed work on Friday. It is understood that the dispute arose when the strikers requested that a plate moulder, alleged to be in arrears with his union subscriptions, should be dismissed. The firm took the view that they could not interfere with a union's internal matters, and that the strike threat was unconstitutional, and they refused to dismiss the man, who, they said, had proved a satisfactory workman. The 200 men thereupon downed tools.

AT THE 36TH ANNUAL CONVENTION of the International Acetylene Association, which has just been held at Cleveland, U.S.A., Mr. A. B. Harrower, of the British Oxygen Company, Limited, representing the British Acetylene Association, extended an invitation to members of the International Acetylene Association to attend the 12th International Congress of Acetylene Welding and Allied Industries, to be held in London next June. In this connection he read a number of messages from prominent British and European members of the industry. The 1936 Congress marks the centenary of the discovery of acetylene, as a gas, by Davy in 1836. In addition to technical sessions, a programme of social activities, and a visit to two of the London works of the British Oxygen Company, are being arranged.

THE FOLLOWING have been elected to membership of the British Cast Iron Research Association:—Ordinary members: Bertrams, Limited, Edinburgh (representative, Mr. J. I. Melvin); British Aluminium Company, Limited, London (representative, Mr. I. D. Taverner); the Butterley Company, Limited, Derby (representative, Mr. FitzHerbert Wright); Coltness Iron Company, Limited, Newmains, Lanarkshire (representative, Mr. J. Gibb); Canadian General Electric Company, Limited, Toronto, Canada (representative, Mr. M. P. White); Hayward-Tyler & Company, Limited, Luton (representative, Mr. H. W. Howard); R. J. Hunt & Son, Limited, Birmingham (representative, Mr. F. Harvey); the Renishaw Iron Company, Limited, near Sheffield (representative, Mr. J. F. Stanier); Westwood & Wright, Limited, Brierley Hill (representative, Mr. F. L. Wright). Trade member: Longhill Foundry, Limited, West Hartlepool, Co. Durham (representative, Mr. A. J. Snodgrass, M.Inst.P.E.). Associate member: Mr. T. H. Gameson, Birmingham.

Contracts Open

New Delhi, January 16.—Cast-iron pipes and specials, for the Indian Stores Department. The Department of Overseas Trade. (Reference T.Y. 5,514.)

Southport, December 16.—3-in. to 6-in. dia. cast-iron pipes and specials, for the Southport and District Water Board. The Engineer and Manager, 14, Portland Street, Southport. (Fee £1, returnable.)

Christchurch, December 17.—Provision and laying of 10 miles of 6-in. and 12-in. iron or G.S.S. pipe sewers, with manholes, etc., for the Town Council. Major W. H. Bateman, Batheaston, Bath. (Fee £5 5s., returnable.)

Dursley, December 11.—Providing and laying 440 yds. of 3-in. and 900 yds. of 4-in. spun cast-iron mains, and other works, for the Rural District Council. Mr. F. J. Smart, clerk, the Institution, Dursley, Glos. (Fee £1 1s., returnable.)

Boosbeck, December 9.—Providing and laying 1,900 yds. of 9-in. and 7-in. cast-iron and earthenware pipes, with manholes, etc., for the Skelton and Brotton Urban District Council. Messrs. D. Balfour & Sons, civil engineers, 3, Nicholas Buildings, Newcastle-upon-Tyne. (Fee £3, returnable.)

Audley, December 14.—Provision and laying of 4,650 yds. of 10-in. dia. cast-iron rising main and construction of a pumping station on piled foundations, for the Newcastle-under-Lyme Rural District Council. Mr. A. H. S. Waters, 25, Temple Row, Birmingham, 2. (Fee £3 3s., returnable.)

Bakewell, December 21.—Providing, laying and jointing six miles of 3-in. and 4-in. dia. iron pipes, with valves, hydrants and other fittings; construction of a mass concrete service tank of 26,000 galls. capacity, and other works, for the Bakewell Rural District Council. Messrs. Brady & Partington, Market Street, Chapel-en-le-Frith. (Fee £5, returnable.)

Personal

MR. A. M. CLEVERLEY, has changed his address from 83, Ashleigh Street, Keighley, to "Brooklands," Greenfield, near Oldham.

SIR G. G. GOODWIN has retired from the board of Messrs. J. Samuel White & Company, Limited.

LORD HERBERT SCOTT has been elected a director of the Westinghouse Brake & Signal Company, Limited.

Wills

MILNER, C. N., a director of Messrs. Benton & Stone, Limited, brassfounders, of Birmingham £81,328

HARDING, R. C., of Newport, general manager of the Rogerstone Works of Messrs. Guest, Keen & Nettlefolds, Limited £23,273

PEECH, J. E., steel manufacturer, a director of the United Steel Companies, Limited, and of the Appleby-Frodingham Steel Company, Limited £4,886

GOULDING, SIR WILLIAM L. A., BT., of Dublin, a director of the National Smelting Company, Limited, and the Metropolitan-Vickers Electrical Company, Limited £38,828

Obituary

MR. DAVID H. NIVEN, who has died at the age of 70, joined the Carron Company in 1883, where he was employed for 50 years, retiring about 18 months ago, on account of ill-health. On the occasion of his retirement he was made the recipient of a presentation.

New Company

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

South Staffs Foundry, Limited.—Capital £1,000. To acquire the business of ironfounders, etc., carried on by W. O. Spinks and P. Powell at Cross Street North, Wolverhampton, as the "General Rainwater Castings Company." Directors: Joseph Dudley, W. O. Spinks and Percy Powell.

Forthcoming Events

Institute of British Foundrymen

DECEMBER 7.

Falkirk Section:—"Metal Finishes on Cast Iron," Paper by H. Cowan, B.Sc., at the Temperance Café, Lint Riggs, Falkirk, at 6 p.m.

Wales and Monmouth Branch:—"The Control of the Properties of Pig-Iron," Paper by J. E. Hurst at University College, Newport Road, Cardiff, at 6.30 p.m.

Lancashire Branch:—"The Dagenham Foundry of the Ford Motor, Limited," Paper by V. C. Faulkner and J. N. Burns, at the Engineers' Club, Albert Square, Manchester, at 4 p.m.

DECEMBER 12.

London Branch:—"Die-Casting of Non-Ferrous Alloys," Paper by N. D. G. Robertson. Joint meeting with the London Section of the Institute of Metals, at the Society of Motor Manufacturers and Traders, Limited, 83, Pall Mall, London, S.W.1, at 7.30 p.m.

DECEMBER 13.

Middlesbrough Branch:—Debate, "That the Scientific Aspect of the Modern Ironfoundry is of Greater Value to the Industry than the Development of Skilled Labour." Proposed by D. Guthrie, and opposed by G. B. Taylor. Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, at 7.45 p.m.

DECEMBER 14.

West Riding of Yorkshire Branch:—Open discussion on subjects raised by members at the Technical College, Bradford, at 6.30 p.m.

Newcastle-upon-Tyne Branch:—Discussion on "Strickle Moulding of Large Castings," at the Neville Hall, Westgate Road, Newcastle-upon-Tyne, at 6.15 p.m.

Scottish Branch:—(1) Paper on "Metal Spraying"; (2) Annual Dinner.

East Midlands Branch:—"A Comparison of Some Melting Furnaces in a Grey Iron Foundry." Paper by T. R. Twigger, at the College of Technology, Leicester, at 6 p.m.

The Institute of Vitreous Enamellers

DECEMBER 12.

London:—"Heat-Resisting Alloys," Paper by J. Ferdinand Kayser, at British Industries House, Marble Arch, London, W.1, at 8 p.m.

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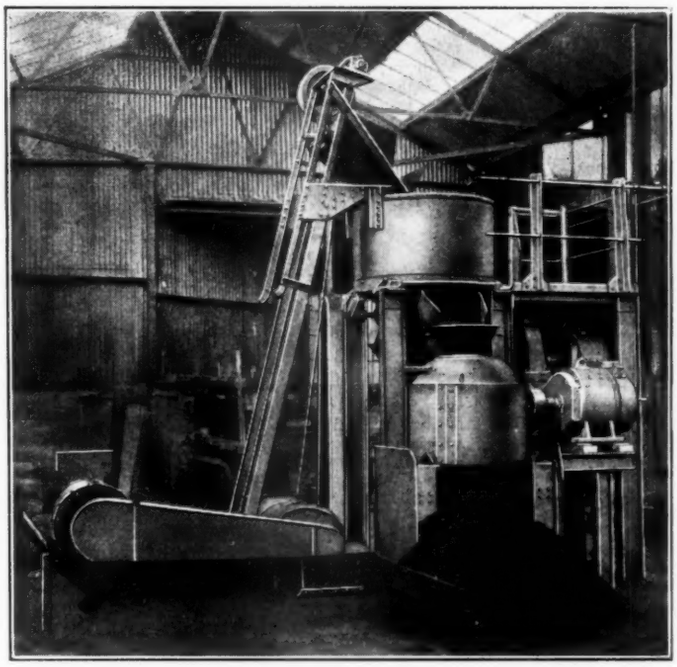

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Raw Material Markets

Consumers of iron and steel continue to have very heavy requirements and, although they have increased their output, producers are finding it difficult to meet the demand. A blast furnace has recently been blown in in the Cleveland district, but this will produce iron for steel-making purposes and so will not increase the supplies of marketable iron. The output of semi-finished steel in the West of Scotland will be considerably increased when the plans for doubling the output of the Glengarnock works of Messrs. Colvilles, Limited, are put into effect.

Pig-Iron

MIDDLESBROUGH.—Business in this area during the past week has chiefly consisted of small parcels of iron to supplement running contracts. Forward buying is being entered into with caution by the ironmasters, as they are already committed over the first few months of next year. The number of blast furnaces in operation in this area has been increased to 27 by the starting up of an additional furnace last week. The output of this furnace will go into direct consumption in the steel plant and consequently will not relieve the supply position. Active conditions continue in the Scottish light-castings trade, but the limited supplies prevent excessive shipments being made to Grangemouth and Bo'ness, where large tonnages of Midland iron are also being used. The quotations for Midland iron continue to be 1s. 3d. per ton below the fixed delivered prices of No. 3 Cleveland G.M.B., which are 70s. in the Falkirk district and 73s. on Clydeside. For delivery to Middlesbrough 70s. per ton is quoted for the same grade, and for elsewhere on the North-East Coast, 72s. per ton is the figure.

Inquiries for hematite supplies, both for prompt and forward delivery, are numerous, but makers are not anxious to book ahead. Prices have not yet been advanced, but this move is expected in the near future. Makers are disposing of their output easily and the amount of iron available for export purposes is very small. Nominal quotations for No. 1 East Coast quality, delivered to consumers' works, are 71s. per ton in the Middlesbrough area, 72s. on Tyneside, 73s. 6d. elsewhere on the North-East Coast, 74s. in Scotland, 78s. 6d. in Sheffield and 84s. 6d. in the Midlands.

LANCASHIRE.—Buyers are taking out iron fairly freely against existing commitments. Good tonnages of iron and steel are being consumed by the heavy motor vehicle trades, while steady deliveries are being made to machine-tool makers, heavy electrical engineers, and the jobbing foundries. Prices of pig-iron are firm all round, with Staffordshire, Derbyshire, and Lancashire brands of No. 3 equal to Derbyshire, all quoted for delivery to Lancashire consumers on the basis of 78s. per ton, with Northamptonshire at 76s. 6d. and Scottish foundry at about 83s. 6d. per ton. As yet the basis of hematite for delivery in this area is unchanged, but an advance is looked for in the near future. A satisfactory local demand for both East and West Coast brands exists, with West Coast iron quoted in the neighbourhood of 81s. per ton, for delivery equal to Manchester, and East Coast at from 80s. 6d. to 81s.

MIDLANDS.—There has been an increase in the number of contracts placed for pig-iron during the past week. Most ironfounders are, however, already covered for fairly large contracts to meet their needs until the end of June, and in some cases beyond this period. A meeting of the pig-iron producers was held recently, but no alterations in prices were made. The present controlled figures delivered Birmingham and Black Country stations are 72s. 6d. for Northants No. 3 and 75s. for Derbyshire, Lincolnshire and North Staffordshire No. 3. There is an extra 2s. 6d. per ton on any iron from the latter sources where the phosphorus is between 0.75 per cent. and 1 per cent. All prices are subject to a small sliding-scale rebate to large consumers. The demand for forge pig-iron continues to be maintained at an improved level and the price is 5s. per ton below ordinary No. 3. Special iron and hematite are both receiving good inquiries and prices are unchanged, with the controlled quotation for West Coast mixed numbers at £4 4s. 6d., for East Coast No. 3 £4 3s. 6d. and for Welsh mixed numbers £4 3s., delivered Birmingham and district stations, with 1s. 6d. extra if delivered into works. Prices of other special irons, apart from hematite, are firm and unchanged. Quotations vary according to quality and the transport costs. Low-phosphorus irons are on offer at between 89s. and 92s. 6d., including Scottish at 90s., medium-phosphorus 75s. to 80s. 6d., and refined pig-iron £5 7s. 6d. to £7 10s. per ton delivered this district.

SCOTLAND.—Satisfactory conditions continue to exist on the pig-iron market here. The official minimum for No. 3 foundry is 74s. f.o.t. furnaces, with 2s. 6d. extra for No. 1. The light-castings founders continue to be well employed. No. 3 Cleveland is quoted at 70s. f.o.t. Falkirk and 73s. f.o.t. Glasgow, with other English foundry irons at 1s. 3d. per ton less. There is a heavy call on the steelworks for supplies, and their output is being severely taxed. Quotations are:—Mixed numbers Scottish hematite, 73s. 6d.; mixed numbers West Coast hematite, 74s.; mixed numbers East Coast hematite, 74s.; basic, British and Indian, 70s. (less 5s. rebate), all delivered f.o.t. steelworks in this area.

Coke

Several foundry coke producers have now withdrawn from the market, having sold very heavily. Complaints of slow deliveries are being received in most districts, and should the present level of buying be maintained it is probable that further increases in prices will be made. Prices have been raised slightly during the past week, and for delivery in Birmingham and district best Durham coke is quoted between 38s. 6d. and 41s. 6d., with Welsh from 34s. to 46s., while Scottish coke is on offer in limited quantities at 41s. 6d. to 43s. per ton.

Steel

While the British steel industry is actively employed in practically all departments, there has been a slight decrease in the volume of new business, says the official report of the London Iron and Steel Exchange. This, however, is a seasonal movement, and is generally noticeable on the approach of the end of the year. Deliveries against contracts continue to be made on a heavy scale, and in many departments the producing works are unable to keep pace with consumers' requirements. There is a strong demand for semi-finished steel, supplies of which are barely sufficient to satisfy consumers' needs, notwithstanding the heavy output of this class of steel. Generally speaking, this branch of the industry is producing at capacity, and in a number of cases works are unable to accept further orders. Business in finished steel remains active, and the consuming industries are calling for considerable quantities, particularly the constructional engineers and the shipbuilders. The demand is principally for the home market, and although oversea consumers have taken more interest in the market lately, this side of the trade improves only slowly.

Scrap

Good quality scrap is becoming increasingly difficult to obtain on the Cleveland market. Heavy steel scrap remains nominally at 52s. 6d. per ton, and foundry cast-iron scrap has a good sale at the same figure. Machinery metal is unchanged at 57s. 6d., while clean, light cast iron is being taken up at 45s. Cast-iron borings are quoted at 27s. 6d. per ton delivered buyers' works. Conditions on the South Wales market remain rather inactive owing to the shortage of material at current figures. Local steelworks are in the market, but they will not advance their offers. Heavy cast iron in large pieces and furnace sizes has a moderate sale at 54s. and cast-iron machine scrap in foundry sizes is quiet at 57s. 6d. to 60s. per ton. Prices on the Midland market are firm and a little more selling is taking place. Short, heavy steel scrap, as used in the foundries, is at 57s. 6d. per ton, delivered works. A firm market for all qualities of scrap exists in Scotland and the demand is heavy. Heavy mild-steel melting scrap, in furnace sizes, from local sources, remains at 50s., with heavy basic or heavy iron and steel scrap mixed, 5s. per ton less. Machinery cast-iron scrap, suitable for cupolas and in pieces not exceeding 1 cwt., is difficult to obtain at 61s. 3d. to 62s. 6d. Steelworks cast-iron scrap is firm around 52s. 6d., with light cast iron at 45s. to 47s. 6d. per ton.

Metals

Copper.—This market has been steady during the past week, with business on a rather restricted scale. Consumption is reported to have been well maintained, and some consumers have been in the market for the purpose of replenishing their stocks. In the United States business has been quiet, but reports state that an active demand is expected early next year. It is said that consumers are being asked to stipulate their requirements well ahead. The future of this metal is looked upon favourably in view of the fact that world stocks are decreasing every month.

Daily market prices:—

Cash.—Thursday, £35 2s. 6d. to £35 3s. 9d.; Friday, £35 3s. 9d. to £35 5s.; Monday, £35 11s. 3d. to £35 12s. 6d.; Tuesday, £35 8s. 9d. to £35 10s.; Wednesday, £35 11s. 3d. to £35 12s. 6d.

Three Months. — Thursday, £35 10s. to £35 11s. 3d.; Friday, £35 11s. 3d. to £35 12s. 6d.; Monday, £35 18s. 9d. to £36; Tuesday, £35 17s. 6d. to £35 18s. 9d.; Wednesday, £36 to £36 1s. 3d.

Tin. — Consumption of this metal has been maintained on quite a good scale. Stocks have been augmented recently by the arrival of a considerable tonnage of Banka and Tulip tin from Holland and, while part of this metal has been put on warrant, some has been accounted for by private sales. Continental business has been moderate during the past week. Conditions in the United States have been irregular, although quite a good trade has been reported. The tinplate and motor industries have been good consumers in the United States.

Metal Exchange quotations were as follow:—

Cash.—Thursday, £220 10s. to £221; Friday, £221 10s. to £222; Monday, £223 to £223 10s.; Tuesday, £224 10s. to £225; Wednesday, £224 5s. to £224 15s.

Three Months.—Thursday, £211 10s. to £212; Friday, £211 5s. to £211 15s.; Monday, £213 to £213 10s.; Tuesday, £213 5s. to £213 10s.; Wednesday, £213 10s. to £213 15s.

Spelter.—This market has been rather less active recently, but prices have remained steady. Consumption of high-grade metal has been well maintained. The European brass industries continue to be very active, but the recent improvement in the galvanising trade has almost disappeared. Some encouragement has been given to the market by Sir Robert Horne's remarks concerning the revival of the International Zinc Cartel.

Official quotations were as follow:—

Ordinary.—Thursday, £16; Friday, £15 18s. 9d.; Monday, £15 13s. 9d.; Tuesday, £15 12s. 6d.; Wednesday, £15 15s.

Lead.—The increased demand which was noticeable at the beginning of last week has not been maintained, and prices have since fallen again. However, consumption has remained on a good scale, with prospects of a further increase. According to the American Bureau of Metal Statistics, the estimated world output of refined lead was 120,326 short tons in September, as compared with 126,971 tons in the previous month.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £17 17s. 6d.; Friday, £17 18s. 9d.; Monday, £17 12s. 6d.; Tuesday, £17 15s.; Wednesday, £17 15s.

Company Reports

Millom & Askam Hematite Iron Company, Limited.—The directors have decided to withhold payment of a preference dividend.

Allied Ironfounders, Limited.—Interim dividends of 3½ per cent. (actual) on the preference shares and 4 per cent. (actual) on the ordinary shares will be paid on December 31.

R. A. Lister & Company, Limited.—Profit, after depreciation, £112,678; to taxation reserve, £22,522; preference dividend, £13,950; dividend of 10 per cent. on the ordinary shares, £29,062; directors' commissions and staff bonus, £14,329; to pension reserve, £10,000; to general reserve, £15,000; carried forward, £58,805.

David Brown & Sons (Huddersfield), Limited.—Profit, after depreciation, £88,083; brought in, £87,761; tax, £17,944; special depreciation and amounts written off engineering premises, plant, etc., £35,207; dividends on preference shares for year, £14,975; dividend on the ordinary shares of 4 per cent.; carried forward, £99,277.

XUM

WM. CUMMING & CO. LTD.

Established 1840.

The Leading Manufacturers!
The Oldest Established!!
The Most Reliable!!!

Ironfounders' Facings Manufacturers and General Foundry Furnishers,

Kelvinvale Mills, Maryhill, GLASGOW

Branches at Falkirk, Chesterfield, Deepfields and Middlesbrough

CUMMING'S CFF FOUNDRY FACINGS

CUMMING'S CPP PARTING POWDER

CUMMING'S CCC CORE COMPOUND

CUMMING'S CRIC RELIABLE IRON CEMENT

SUPERFINE COAL DUST
SUPERLATIVELY REGULAR IN GRIST.
SUPERIOR IN QUALITY.
SEVEN GRISTS STANDARDISED.
ONE QUALITY OF COAL THROUGHOUT.

INGOT MOULD BLACKING
THE BEST ON THE MARKET.
MANUFACTURED BY THE NEW PROCESS.

BRITISH PLUMBAGOS
AT LOW PRICES.
IMPORTED DIRECT.
NO CONTINENTAL ADULTERATION.

POWDERED CORE GUM
BRITISH MANUFACTURE.
BEST QUALITY.

CUMMING FURNACE
USERS OF THE NEW "CUMMING" FURNACE ARE INCREASING WEEK BY WEEK.

CORE COMPOUNDS, PARTINGS, CUMMINGSTONE, REQUISITES, BLACKINGS for every PURPOSE

ALL OUR OWN MAKE

RAW MATERIALS—PRICE LIST

(Wednesday, December 4, 1935)

COPPER

	£ s. d.
Standard cash	35 11 3
Three months	36 0 0
Electrolytic	39 15 0
Tough	38 5 0
Best selected	38 15 0
Sheets	66 0 0
India	49 10 0
Wire bars	39 15 0
Ingot bars	39 15 0
H.C. wire rods	43 10 0
Off. av. cash, Nov.	35 5 4⅝
Do., 3 mths., Nov.	35 12 8½
Do., Sttlmnt., Nov.	35 5 4⅜
Do., Electro. Nov.	39 12 1 5/16
Do., B.S., Nov.	39 2 6
Do., wire bars, Nov.	39 16 3⅝
Solid drawn tubes	10½d.
Brazed tubes	10½d.
Wire	6½d.

BRASS

Solid drawn tubes	9¾d.
Brazed tubes	11¾d.
Rods, drawn	8¾d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	7¾d.
Wire	7¾d.
Rolled metal	7¾d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5¾d.
Do. 4 × 3 Sheets	5¾d.

TIN

	£ s. d.
Standard cash	224 5 0
Three months	213 10 0
English	224 5 0
Bars	225 10 0
Straits (nom.)	227 5 0
Australian (nom.)	224 5 0
Eastern	219 5 0
Banca (nom.)	225 5 0
Off. av. cash, Nov.	226 16 10½
Do., 3 mths., Nov.	212 18 2½
Do., Sttlmt., Nov.	226 15 11⅞

SPELTER

	£ s. d.
Ordinary	15 15 0
Remelted	14 15 0
Hard	12 15 0
Electro 99.9	18 5 0
English	16 12 6
India	14 5 0
Zinc dust	19 10 0
Zinc ashes	4 15 0
Off. aver., Nov.	16 5 7⅜
Aver. spot, Nov.	16 3 10⅜

LEAD

	£ s. d.
Soft foreign ppt.	17 15 0
Empire (nom.)	18 10 0
English	19 15 0
Off. average, Nov.	17 18 8 9/14
Average spot, Nov.	17 18 9

ALUMINIUM

Ingots	£100 to £105
Wire	1/1 to 1/9 lb.
Sheet and foil	1/2 to 2/9 lb.

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	24 0 0
Do., V.M. ex-whse.	25 0 0
Rods	28 15 0

ANTIMONY

	£ s. d. to £ s. d.
English	76 0 0 to 77 0 0
Chinese, ex-whse.	64 0 0
Crude, c.i.f.	34 0 0

QUICKSILVER

	£ s. d. to £ s. d.
Quicksilver	12 2 6 to 12 12 6

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	8 17 6
45/50%	12 15 0
75%	17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
23/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£18 0 0 to £20 0 0
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	33 0 0
4/6% car.	21 15 0
6/8% car.	21 0 0
8/10% car.	21 0 0
Ferro-chrome—	
Max. 2% car.	33 10 0
Max. 1% car.	36 5 0
Max. 0.70% car.	37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	5/6 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese (net)—	
76/80% loose	£10 15 0 to 11 5 0
76/80% packed	£11 15 0 to 12 5 0
76/80% export	(nom.) £9 15 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales—		
Heavy steel	3 0 0	to 3 2 6
Mixed iron and steel	2 15 0	to 2 16 0
Heavy cast iron		2 14 0
Good machinery	2 17 6	to 3 0 0
Cleveland—		
Heavy steel		2 12 6
Steel turnings		1 17 6
Cast-iron borings		1 7 6
Heavy cast iron		2 12 6
Heavy machinery		2 17 6
Midlands—		
Light cast-iron scrap		2 7 6
Heavy wrought iron		3 0 0
Steel turnings		1 16 6
Scotland—		
Heavy steel		2 10 0
Ordinary cast iron	2 17 6	to 2 18 6
Engineers' turnings		2 0 0
Cast-iron borings	1 18 6	to 2 0 0
Wrot-iron piling	3 2 6	to 3 5 0
Heavy machinery	3 1 3	to 3 2 6

London—Merchants' buying prices, delivered yard.

	£ s. d.
Copper (clean)	29 0 0
Brass	19 0 0
Lead (less usual draft)	15 10 0
Tea lead	12 0 0
Zinc	9 0 0
New aluminium cuttings	72 0 0
Braziery copper	26 0 0
Gunmetal	27 0 0
Hollow pewter	155 0 0
Shaped black pewter	120 0 0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	72/6
Foundry No. 3	70/-
,, at Falkirk	70/-
,, at Glasgow	73/-
Foundry No. 4	69/-
Forge No. 4	69/-
Hematite No. 1	71/-
Hematite M/Nos.	70/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	74/-
,, d/d Birm.	84/6
Malleable iron d/d Birm.	115/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	71/-
,, No. 3 fdry.	75/-
Northants forge	68/6
,, fdry. No. 3	72/6
,, fdry. No. 1	75/6
Derbyshire forge	71/-
,, fdry. No. 3	75/-
,, fdry. No. 1	78/-
Scotland—	
Foundry No. 1, f.o.t.	76/6
,, No. 3, f.o.t.	74/-
Hem. M/Nos. d/d	73/6
Sheffield (d/d district)—	
Derby forge	68/6
,, fdry. No. 3	72/6
Lincs forge	68/6
,, fdry. No. 3	72/6
W.C. hematite	86/-
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	78/-
Staffs fdry. No. 3	78/-
Northants fdry. No. 3	76/6
Cleveland fdry. No. 3	78/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	83/6
Clyde, No. 3	83/6
Monkland, No. 3	83/6
Summerlee, No. 3	83/6
Eglinton, No. 3	83/6
Gartsherrie, No. 3	83/6
Shotts, No. 3	83/6

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£ s. d.	£ s. d.
Bars (cr.)	9 12 6	to 9 15 0
Nut and bolt iron	7 17 6	to 8 7 6
Hoops	10 10 0	and up.
Marked bars (Staffs)	f.o.t. 12 0 0	
Gas strip	10 10 0	and up.
Bolts and nuts, ¾ in. × 4 in.	15 2 6	and up.
Steel—		
Plates, ship, etc.	8 15 0	to 8 17 6
Boiler plts.	9 5 0	to 9 7 6
Chequer plts.	10 7 6	
Angles	8 7 6	
Tees	9 7 6	
Joists	8 15 0	
Rounds and squares, 3 in. to 5½ in.	9 7 6	
Rounds under 3 in. to ⅜ in. (Untested)	8 12 0	
Flats—8 in. wide and over	8 12 6	
,, under 8 in. and over 5 in.	8 17 6	
Rails, heavy	8 5 0	to 8 10 0
Fishplates	12 5 0	to 12 10 0
Hoops (Staffs)	9 7 0	
Black sheets, 24g. (4-t. lots)	11 5 0	
Galv. cor. shts. (,,)	13 5 0	
Galv. flat shts. (,,)	13 15 0	
Galv. fencing wire, 8g. plain	14 10 0	
Billets, soft	5 10 0	and up.
Billets, hard	6 17 6	to 7 2 6
Sheet bars	5 10 0	to 5 15 0
Tin bars	5 10 0	to 5 15 0

PHOSPHOR BRONZE

	Per lb. basis.
Strip	10½d
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	11½d.
Tubes	14d.
Castings	12½d.

Delivery 3 cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	14.50
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	85.00
O.-h. rails, h'y, at mill	36.37½
Billets	29.00
Sheet bars	30.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.85
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Steel hoops	2.10
Sheets, black, No. 24	2.40
Sheets, galv., No. 24	3.10
Wire nails	2.40
Plain wire	2.30
Barbed wire, galv.	2.80
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	25/- to 30/-
,, furnace	19/- to 20/-
Durham foundry	21/6
,, furnace	17/6 to 18/9
Scotland, foundry	28/-
,, furnace	25/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes 20 × 14 per box	18/9
,, 28 × 20 ,,	37/6
,, 20 × 10 ,,	27/-
,, 18¾ × 14 ,,	19/6
C.W. 20 × 14 ,,	15/6 to 16/-
,, 28 × 20 ,,	33/6 to 34/6
,, 20 × 10 ,,	22/9 to 23/-
,, 18¾ × 14 ,,	15/9 to 16/-

SWEDISH CHARCOAL IRON & STEEL

	£ s. d. to £ s. d.
Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£30 0 0 to £31 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.		
Nov. 28 ..	35	2	6	No	change
„ 29 ..	35	3	9	inc.	1/3
Dec. 2 ..	35	11	3	„	7/6
„ 3 ..	35	8	9	dec.	2/6
„ 4 ..	35	11	3	inc.	2/6

Electrolytic Copper

	£	s.	d.		
Nov. 28 ..	39	0	0	No	change
„ 29 ..	39	0	0	„	„
Dec. 2 ..	39	10	0	inc.	10/–
„ 3 ..	39	10	0	No	change
„ 4 ..	39	15	0	inc.	5/–

Standard Tin (cash)

	£	s.	d.		
Nov. 28 ..	220	10	0	dec.	20/–
„ 29 ..	221	10	0	inc.	20/–
Dec. 2 ..	223	0	0	„	30/–
„ 3 ..	224	10	0	„	30/–
„ 4 ..	224	5	0	dec.	5/–

Tin (English ingots)

	£	s.	d.		
Nov. 28 ..	221	0	0	dec.	10/–
„ 29 ..	221	10	0	inc.	10/–
Dec. 2 ..	223	0	0	„	30/–
„ 3 ..	224	10	0	„	30/–
„ 4 ..	224	5	0	dec.	5/–

Spelter (ordinary)

	£	s.	d.		
Nov. 28 ..	16	0	0	dec.	2/6
„ 29 ..	15	18	9	„	1/3
Dec. 2 ..	15	13	9	„	5/–
„ 3 ..	15	12	6	„	1/3
„ 4 ..	15	15	0	inc.	2/6

Spelter (Electro, 99.9 per cent.)

	£	s.	d.		
Nov. 28 ..	18	11	3	dec.	2/6
„ 29 ..	18	8	9	„	2/6
Dec. 2 ..	18	6	3	„	2/6
„ 3 ..	18	2	6	„	3/9
„ 4 ..	18	5	0	inc.	2/6

Zinc Sheets (English)

	£	s.	d.		
Nov. 28 ..	24	5	0	dec.	5/–
„ 29 ..	24	3	9	„	1/3
Dec. 2 ..	24	2	6	„	1/3
„ 3 ..	24	0	0	„	2/6
„ 4 ..	24	0	0	No	change

Lead (English)

	£	s.	d.		
Nov. 28 ..	20	0	0	No	change
„ 29 ..	20	0	0	„	„
Dec. 2 ..	19	15	0	dec.	5/–
„ 3 ..	19	15	0	No	change
„ 4 ..	19	15	0	„	„

A COMPARISON OF SCRAP PRICES

Prices of Heavy Steel Scrap (Delivered) in the Principal Districts at the Beginning of Each Month in the Years 1929–1935.

Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Scotland—													
1929	3 5 6	3 7 6	3 12 6	3 15 0	3 15 0	3 15 0	3 15 6	3 16 0	3 17 6	3 15 0	3 12 6	3 10 6	3 13 1½
1930	3 9 0	3 7 6	3 5 0	3 5 0	3 0 6	2 15 0	2 12 0	2 10 0	2 13 3	2 10 0	2 10 0	2 10 0	2 17 3½
1931	2 7 6	2 7 6	2 5 0	2 5 0	2 0 0	1 17 6	1 17 6	1 17 6	1 17 6	1 15 0	2 0 0	2 2 6	2 1 0½
1932	2 2 6	2 2 6	2 0 0	1 17 6	1 17 6	1 17 6	1 15 0	1 15 0	1 12 6	1 13 0	1 12 6	1 15 0	1 16 9½
1933	1 15 0	1 17 6	1 18 6	1 18 9	1 18 0	1 17 6	1 18 9	2 0 0	2 2 6	2 5 0	2 7 6	2 8 9	2 0 7½
1934	2 8 9	2 14 3	2 13 0	2 13 0	2 12 0	2 10 0	2 10 6	2 10 6	2 11 0	2 10 9	2 10 0	2 10 0	2 11 2
1935	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	2 10 0	—	—
North-East Coast—													
1929	3 0 0	3 2 6	3 3 6	3 3 6	3 3 6	3 5 0	3 5 0	3 5 0	3 5 0	3 6 6	3 5 0	3 3 6	3 4 0
1930	3 3 6	3 3 6	3 2 0	3 0 0	2 17 6	2 10 0	2 10 0	2 7 6	2 7 6	2 7 6	2 5 0	2 6 0	2 13 4
1931	2 6 0	2 6 0	2 5 0	2 5 0	2 2 6	2 0 0	1 17 6	1 17 6	1 17 6	1 17 6	1 17 6	2 2 6	2 1 2½
1932	2 0 0	2 0 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 15 0	1 12 6	1 15 0	1 17 6	1 15 10
1933	2 0 0	2 0 0	2 5 0	2 0 0	1 15 0	1 17 6	2 2 6	2 2 6	2 3 6	2 5 0	2 7 6	2 7 6	2 2 2
1934	2 10 0	2 16 0	2 10 0	2 7 6	2 7 6	2 10 0	2 9 9	2 10 0	2 10 0	2 10 0	2 11 6	2 11 3	2 10 3½
1935	2 11 6	2 11 9	2 12 0	2 12 0	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	2 12 6	—	—
South Wales—													
1929	3 8 6	3 10 6	3 15 0	4 0 0	4 0 0	3 18 0	3 17 6	3 17 6	3 15 0	3 15 0	3 12 6	3 7 6	3 14 9
1930	3 7 6	3 6 0	3 6 0	3 4 0	3 2 6	2 17 6	2 16 0	2 15 0	2 14 9	2 12 6	2 12 6	2 5 0	2 18 3½
1931	2 5 0	2 7 6	2 7 6	2 7 6	2 5 0	2 2 6	2 0 0	2 0 0	1 18 0	2 2 6	2 5 0	2 7 6	2 4 0
1932	2 6 6	2 6 0	2 5 0	2 2 6	2 2 0	1 19 0	1 17 6	1 18 6	1 18 0	1 18 0	1 17 6	1 18 0	2 0 8½
1933	2 0 0	2 1 6	2 4 0	2 3 6	2 3 6	2 3 0	2 5 0	2 5 0	2 8 0	2 10 0	2 10 0	2 10 0	2 5 3½
1934	2 10 0	2 16 3	2 15 9	2 13 9	2 14 3	2 15 0	2 14 3	2 14 3	2 15 0	2 15 6	2 15 6	2 15 6	2 14 7
1935	2 15 6	2 15 6	2 15 6	2 15 6	2 15 6	2 15 6	2 15 6	2 15 6	2 16 1½	2 17 9	2 19 8	—	—

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

LIMPET

All grades FOUNDRY, HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

CENTRAL CHAMBERS, 93, HOPE ST., GLASGOW, C.2.

ZETLAND ROAD, MIDDLESBROUGH.

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

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